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National Dioxin Study Tier 4 Combustion Sources: Final Test Report Site 1, Sewage Sludge Incinerator SSI-A

Radian Corp., Research Triangle Park, NC

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16. ABSTRACT

This report summarizes the results of a dioxin/furan emissions test of a multiple hearth sewage sludge incinerator equipped with a wet scrubber system for particulate emissions control. The test was the first in a series of thirteen dioxin/furan emissions tests conducted under Tier 4 of the National Dioxin Study. The primary objective of Tier 4 is to determine if various combustion sources are sources of dioxin and/or furan emissions. If any of the combustion sources are found to emit dioxin or furan, the secondary objective of Tier 4 is to quantify these emissions.

Sewage sludge incinerators are one of eight combustion sources categories tested in the Tier 4 program. The tested incinerator was included in the Tier 4 study because it was considered to be fairly typical of the multiple hearth sewage sludge incineration source category.

Data presented in the report include dioxin (tetra through octa homologue +2378 TCDD) and furan (tetra through octa homologue +2378 TCDD) results for both stack samples and ash samples. In addition, process data collected during sampling are also presented.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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Final Test Report — Site 1 Sewage Sludge Incinerator SSI — A

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TIER 4 — COMBUSTION SOURCES

Final Test Report — Site 1
Sewage Sludge Incinerator SSI — A

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Office Of Air And Radiation
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EPA-450/4-84-014j

FOREWORD

This report is the result of a cooperative effort between the Office of Research and Development's Hazardous Waste Engineering Research Laboratory (HWERL) and the Office of Air Quality Planning and Standard's Monitoring and Data Analysis Division (MDAD). The overall management of Tier 4 of the National Dioxin Study was the responsibility of MDAD. In addition, MDAD provided technical guidance for the source test covered by this report. HWERL was directly responsible for the management and technical direction of the source test.

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1.0 INTRODUCTION

This report summarizes the results of a dioxin/furan[a] emissions test of a multiple hearth sewage sludge incinerator equipped with a wet scrubber system for particulate emissions control. The test was the first in a series of thirteen dioxin/furan emissions tests conducted under Tier 4 of the National Dioxin Study. The primary objective of Tier 4 is to determine if various combustion sources are sources of dioxin and/or furan emissions. If any of the combustion sources are found to emit dioxin or furan, the secondary objective of Tier 4 is to quantify these emissions.

Sewage sludge incinerators are one of eight combustion sources categories tested in the Tier 4 program. The tested incinerator was included in the Tier 4 study because it was considered to be fairly typical of the multiple hearth sewage sludge incineration source category.

This test report is organized as follows. A summary of test results and conclusions is provided in Section 2.0, followed by a detailed process description in Section 3.0. The source sampling and analysis plan is outlined in Section 4.0, and the dioxin test data are presented in Section 5.0. Section 6.0 through Section 9.0 present various testing details. These include descriptions of the sampling locations and procedures (Section 6.0), a description of the analytical procedures (Section 7.0), and a summary of the quality assurance/quality control results (Section 8.0). The appendices contain data generated during the field sampling and analytical activities.

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[a] The term "dioxin/furan" and the acronyms PCDD and PCDF as used in this report refer to the polychlorinated dibenzo-p-dioxin and dibenzofuran isomers with four or more chlorine atoms.

2.0 SUMMARY

2.1 SOURCE SAMPLING AND ANALYSIS OVERVIEW

The host plant (Site SSI-A) is a municipal wastewater treatment plant that operates two multiple hearth sewage sludge incinerators. The tested incinerator is designated as incinerator SSI-A for the purpose of this test program. A simplified flow diagram of incinerator SSI-A is shown in Figure 2-1. Particulate emissions from the incinerator are controlled by a wet scrubber system.

Sampling for dioxin and furan emissions was performed simultaneously at the incinerator outlet and the scrubber outlet in each of a series of three test runs conducted on October 8-10, 1984. The gaseous, liquid, and solids sampling performed is summarized in Table 2-1. Dioxin/furan sampling at the incinerator outlet and the scrubber outlet was based on the Modified Method 5 (MM5) sampling protocol developed by the American Society of Mechanical Engineers (ASME) for measuring emissions of chlorinated organic compounds. MM5 train components and train rinses were analyzed for dioxins and furans by EMSL-RTP and ECL-Bay St. Louis, two of three EPA laboratories collectively known as Troika. The dioxin/furan analysis quantified the 2378-TCDD isomer[a] and the tetra- through octa-dioxin/furan homologues present in the samples.

Dioxin/furan precursor analyses were performed on sludge feed samples obtained directly from the belt feeder to the incinerator. The specific dioxin/furan precursors analyzed for were chlorophenols, chlorobenzenes, polychlorinated biphenyls (PCB), and total chlorine. Samples of the No. 2 fuel oil that was fired as auxiliary fuel in the incinerator were taken and analyzed for total chlorine content.

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[a] The terms TCDD and TCDF as used in this report refer to tetrachlorodibenzo-p-dioxin and tetrachlorodibenzofuran respectively. The acronyms PCDD and PCDF as used in this report refer to dioxin and furan homologues with four or more more chlorine atoms.

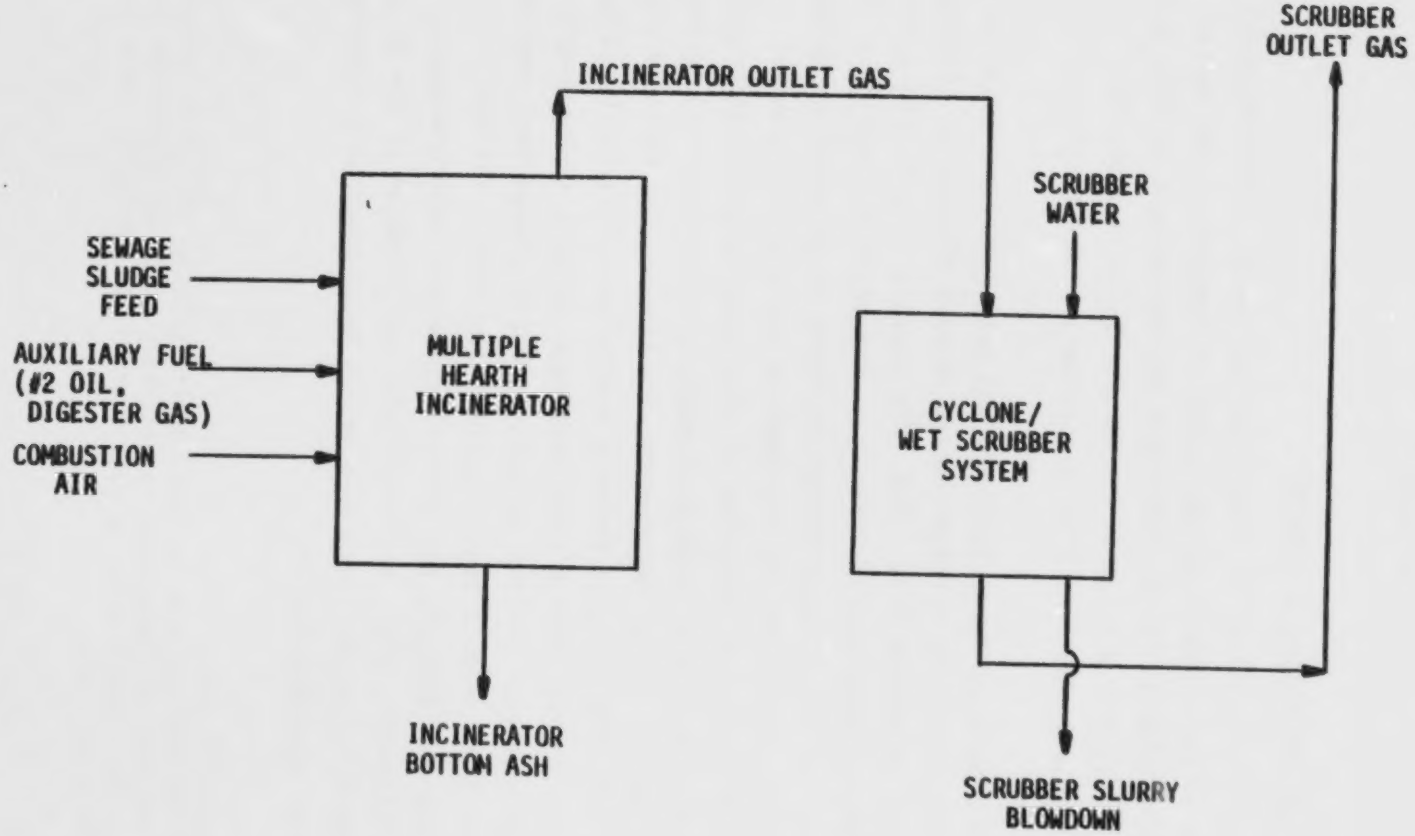

SCRUBBER OUTLET GAS
INCINERATOR OUTLET GAS
SCRUBBER WATER
SEWAGE SLUDGE FEED
AUXILIARY FUEL (#2 OIL, DIGESTER GAS)
COMBUSTION AIR
MULTIPLE HEARTH INCINERATOR
CYCLONE/ WET SCRUBBER SYSTEM
INCINERATOR BOTTOM ASH
SCRUBBER SLURRY BLOWDOWN

Figure 2-1. Simplified Flow Diagram of the Sewage Sludge Incinerator/Wet Scrubber System.

TABLE 2-1. SOURCE SAMPLING AND ANALYSIS OVERVIEW

Item	Item Description
1. Number of test runs	- Three identical test runs (Runs 9, 10, 11).
2. Gaseous Sampling	- Simultaneous incinerator outlet and scrubber outlet MM5 sampling (Runs 9, 10, 11). Dioxin/furan analysis.
	- Simultaneous incinerator outlet and scrubber outlet EPA Reference Methods 2, 3, and 4. (Runs 9, 10, 11).
	- Continuous CO, CO_2, O_2, THC, SO_2, and NO_x monitoring at incinerator outlet (Runs 9, 10, 11).
	- Combustion air sampling at air intake point (one composite test for Runs 9, 10, 11). Potential dioxin/furan and precursor analyses.[a]
3. Liquid and Slurry Sampling	- Scrubber blowdown sampling (Runs 9, 10, 11). Potential dioxin/furan analysis.[a]
	- Fuel oil sampling (Runs 9, 10, 11). Potential dioxin/furan and precursor analyses.[a]
4. Solids Sampling	- Sludge feed sampling (Runs 9, 10, 11). Potential dioxin/furan and precursor analyses.[a]
	- Incinerator bottom ash sampling (Runs 9, 10, 11). Dioxin/furan analysis.
	- Soil sampling (one composite sample from 10 locations). Potential dioxin/furan analysis.[a]

[a] Sample(s) were to be analyzed pending evaluation of the dioxin/furan emissions data from the MM5 sampling train.

Incinerator bottom ash samples were taken during each test run and analyzed by Troika for dioxin/furan content. Scrubber blowdown samples and in-plant air samples were also taken, but these samples were not analyzed. A composite soil sample taken from various plant property locations was transferred to Tier 7 of the National Dioxin Study for potential dioxin/furan analysis.

Continuous emissions monitoring (CEM) was performed at the incinerator outlet for CO, CO_2, NO_x, SO_2, total hydrocarbons (THC), and O_2. These data were taken in conjunction with incinerator process data to document combustion conditions during the test.

2.2 SUMMARY OF RESULTS

Figure 2-2 summarizes the data obtained at Site SSI-A during the Tier 4 test program. According to plant personnel, the multiple hearth incinerator and wet scrubber systen were operated under conditions representative of normal operation during the sampling periods.

Detectable quantities of all targeted dioxin and furan species were found in the scrubber outlet emissions. As shown in Table 2-2, average as-measured scrubber outlet emission concentrations of 2378-TCDD, total PCDD, and total PCDF were 0.006 ng/dscm, 2.85 ng/dscm, and 6.36 ng/dscm, respectively. This corresponds to hourly mass emission rates of 0.089 ug/hr 2378-TCDD, 40.5 ug/hr total PCDD, and 90.4 ug/hr total PCDF. The tetra-chlorinated CDD and CDF homologues were the predominant species present.

Valid analytical data were not obtained by Troika for the incinerator outlet MM5 samples. Unacceptable recovery efficiencies were obtained for the sample extracts, which were reported to be yellow in color. As a result, data on the dioxin/furan removal efficiency of the wet scrubber system were not obtained for this test site.

Incinerator bottom ash samples did not contain detectable quantities of any of the targeted dioxin and furan species. The sludge feed contained .01 ug/g of chlorobenzenes, but polychlorinated biphenyls and chlorophenols were not detected. The average total chlorine concentration of the sludge feed was 606 ug/g. The dry sludge feed rate to the incinerator averaged 877 lb/hr during the test period, and the mean temperatures for individual hearths ranged from 127^{o} to 1438^{o}F.

Incinerator Outlet Flue Gas Parameter Data (E)

Flow Rate:	93.5 dscmm
Temperature:	796°F
Moisture:	28.9 %vol

Scrubber Outlet Flue Gas Parameter Data (F)

Flow Rate:	237.2 dscmm
Temeprature:	173°F
Moisture:	4.1 %vol

As-measured Continuous Monitoring Data (F)

O_2	11.9 %vol
CO_2	14.0 %vol
CO	2470 ppmv
THC	152 ppmv
SO_2	1590 ppmv
NO_x	465 ppmv

Hearth Operating Data (A)

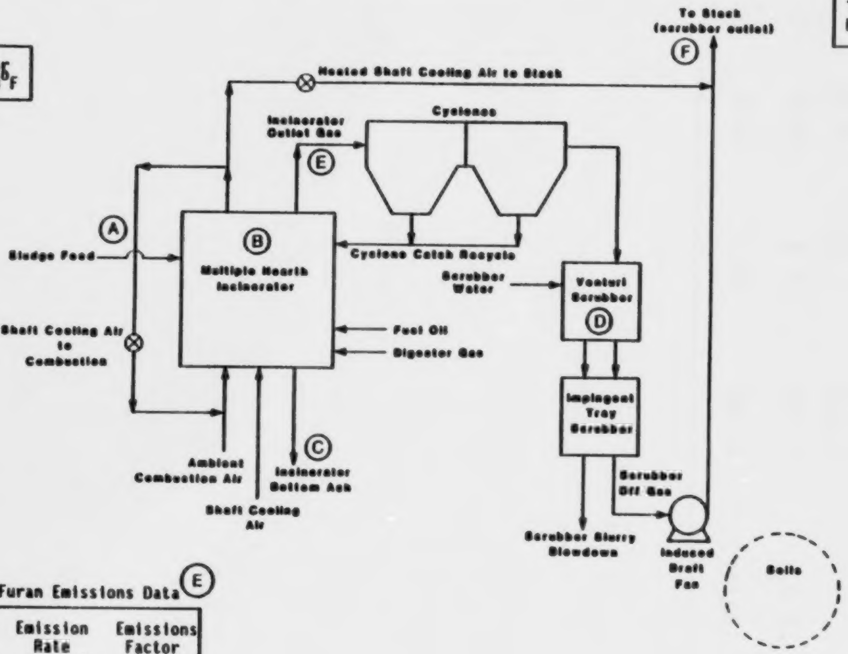
Dry Feed Rate	877 lb/hr
Hearth Temperature	127-1438°F

Scrubber Operating Data (D)

Outlet Temperature	79°F
Liquid:Gas Ratio	.24 gal/dscf
P	23.8 in H_2O

Sludge Feed Precursor Data (A)

	ug/g (ppm)
Chlorobenzenes	0.01
PCB's	ND
Chlorophenols	ND
Total Chloride	606


To Stack (scrubber outlet)
F
Heated Shaft Cooling Air to Stack
Incinerator Outlet Gas
E
Cyclones
A
Sludge Feed
B
Multiple Hearth Incinerator
Cyclone Catch Recycle
Scrubber Water
Venturi Scrubber
D
Shaft Cooling Air to Combustion
Fuel Oil
Digester Gas
Impingement Tray Scrubber
C
Ambient Combustion Air
Incinerator Bottom Ash
Shaft Cooling Air
Scrubber Off Gas
Scrubber Slurry Blowdown
Induced Draft Fan

Sludge Feed Composition (weight %) (A)

% Solids	21.1
% Volatiles	69.3

Bottom Ash Analysis (C)

Species	Concentration (ppt)
2378-TCDD	ND
Total PCDD	ND
Total PCDF	ND

Incinerator Outlet Dioxin/Furan Emissions Data (E)

Species	Concentration (ng/dscm)	Emission Rate (ug/hr)	Emissions Factor (ug/kg)
2378-TCDD	NR	NR	NR
Total PCDD	NR	NR	NR
Total PCDF	NR	NR	NR

NR = Not reported by Troika.

NOTE: Valid data were not obtained for the incinerator outlet location.

Scrubber Outlet Dioxin/Furan Emissions Data (F)

Species	Concentration (ng/dscm)	Emission Rate (ug/hr)	Emissions Factor (ug/kg)
2378-TCDD	0.006	.089	.0002
Total PCDD	2.85	40.5	.103
Total PCDF	6.36	90.4	.230

NOTE: Data shown are as-measured concentrations.

Emissions factors are based on the dry sludge feed rate.

Figure 2-2. Data Summary for Site SSI-A.

TABLE 2-2. SUMMARY OF MEAN DIOXIN/FURAN EMISSIONS DATA FOR SITE SSI-A (OUTLET)

Parameter	2378-TCDD	Total PCDD	Total PCDF
Emissions Concentration (ng/dscm)			
As-measured	0.006	2.84	6.36
Corrected to 3% O_2	0.046	19.6	43.5
Emissions Rate (ug/hr)	0.089	40.5	90.4

Average as-measured incinerator outlet gas concentrations measured by the continuous emissions monitoring system were: O_2, 11.9 vol%; CO, 2470 ppmv; CO_2, 14.0 vol%; THC, 152 ppmv; SO_2, 1590 ppmv; and NO_x, 465 ppmv.

3.0 PROCESS DESCRIPTION

This section describes the host facility and the multiple hearth sewage sludge incinerator/wet scrubber system that was tested. Data summarizing the operation of the incinerator and wet scrubber system during the test periods are presented in Section 5.0.

3.1 FACILITY DESCRIPTION

Site SSI-A is a 14 million gallon per day wastewater treatment plant. A plot plan for the facility is shown in Figure 3-1. Approximately 70 percent of the treatment plant influent is municipal wastewater, and the remaining 30 percent is industrial wastewater. The industrial influent is permitted under an EPA-approved industrial wastewater control program. The only chlorinated organic species permitted to be discharged into the wastewater system is 1,1,1-trichloroethane, which is discharged in small quantities by one industrial source. Aromatic hydrocarbon species permitted to be discharged into the system include fluoranthene and naphthalene.

Plant wastewater influent is processed at the plant as shown in Figure 3-2. Treatment steps include screening, grit removal, primary clarification, aeration, flocculation/secondary clarification, and disinfection with chlorine. Sludges are removed from both the primary and secondary clarifiers.

The primary and secondary sludges are pumped to the solids processing system, which is shown in Figure 3-3. Primary sludge is thickened by chemical addition and gravity thickening, while secondary sludge is thickened by chemical addition and flotation thickening. Chemical thickening agents used are aliphatic polyelectrolyte polymers that do not contain chlorine. The thickened sludges are combined, and can either be sent to an anaerobic digestion unit for volume reduction and fuel gas production, or they can be sent directly to a sludge storage tank with no digestion.

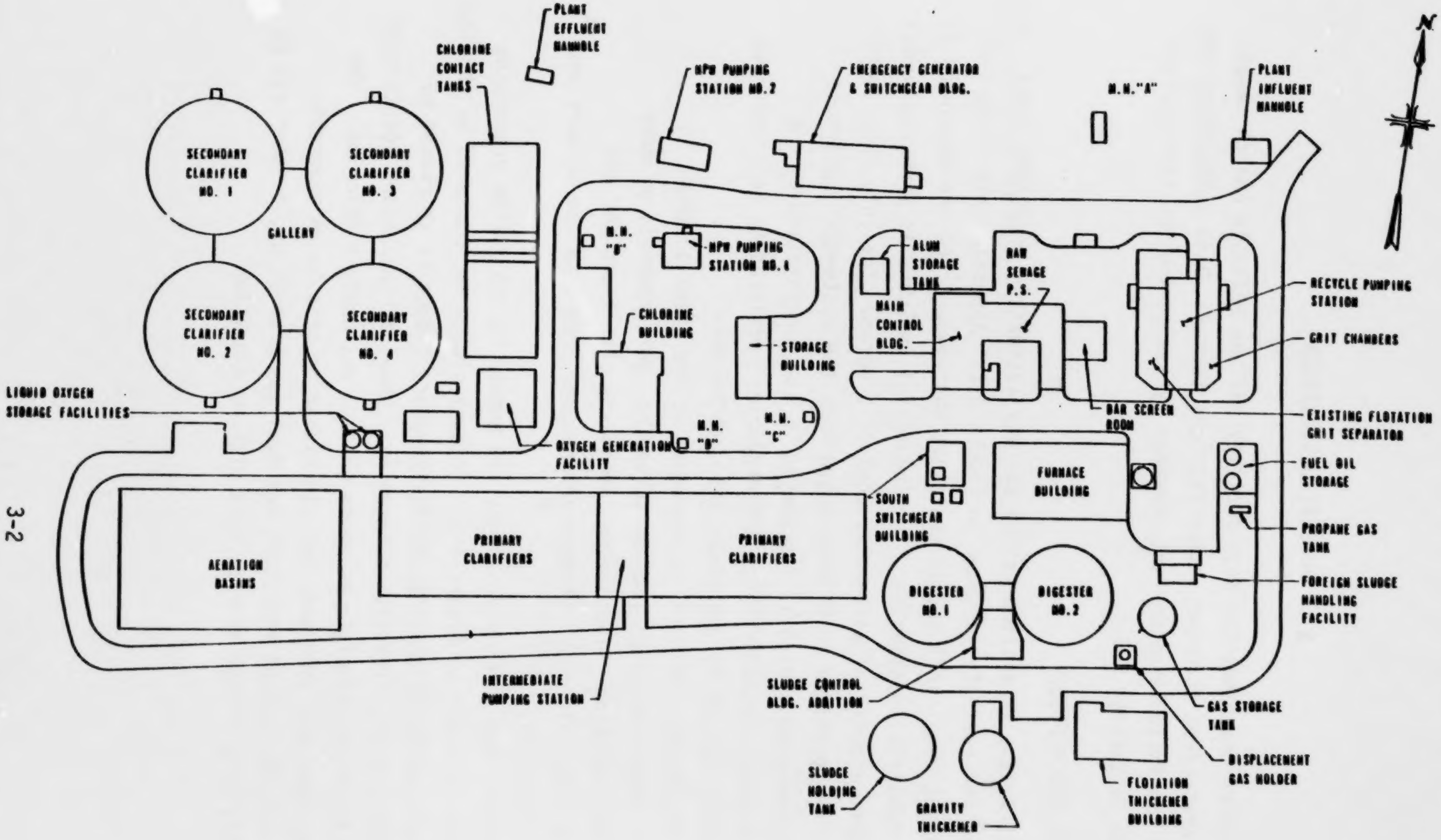

N
PLANT EFFLUENT MANHOLE
CHLORINE CONTACT TANKS
NPW PUMPING STATION NO.2
EMERGENCY GENERATOR & SWITCHGEAR BLDG.
M.H."A"
PLANT INFLUENT MANHOLE
SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER NO. 3
SECONDARY CLARIFIER NO. 2
SECONDARY CLARIFIER NO. 4
GALLERY
M.H. "E"
NPW PUMPING STATION NO.1
CHLORINE BUILDING
STORAGE BUILDING
ALUM STORAGE TANK
RAW SEWAGE P.S.
MAIN CONTROL BLDG.
RECYCLE PUMPING STATION
GRIT CHAMBERS
LIQUID OXYGEN STORAGE FACILITIES
OXYGEN GENERATION FACILITY
M.H. "D"
M.H. "C"
BAR SCREEN ROOM
EXISTING FLOTATION GRIT SEPARATOR
FURNACE BUILDING
FUEL OIL STORAGE
SOUTH SWITCHGEAR BUILDING
PROPANE GAS TANK
AERATION BASINS
PRIMARY CLARIFIERS
PRIMARY CLARIFIERS
DIGESTER NO.1
DIGESTER NO.2
FOREIGN SLUDGE HANDLING FACILITY
INTERMEDIATE PUMPING STATION
SLUDGE CONTROL BLDG. ADDITION
GAS STORAGE TANK
DISPLACEMENT GAS HOLDER
SLUDGE HOLDING TANK
GRAVITY THICKENER
FLOTATION THICKENER BUILDING

Figure 3-1. Plot Plan for Site SSI-A.

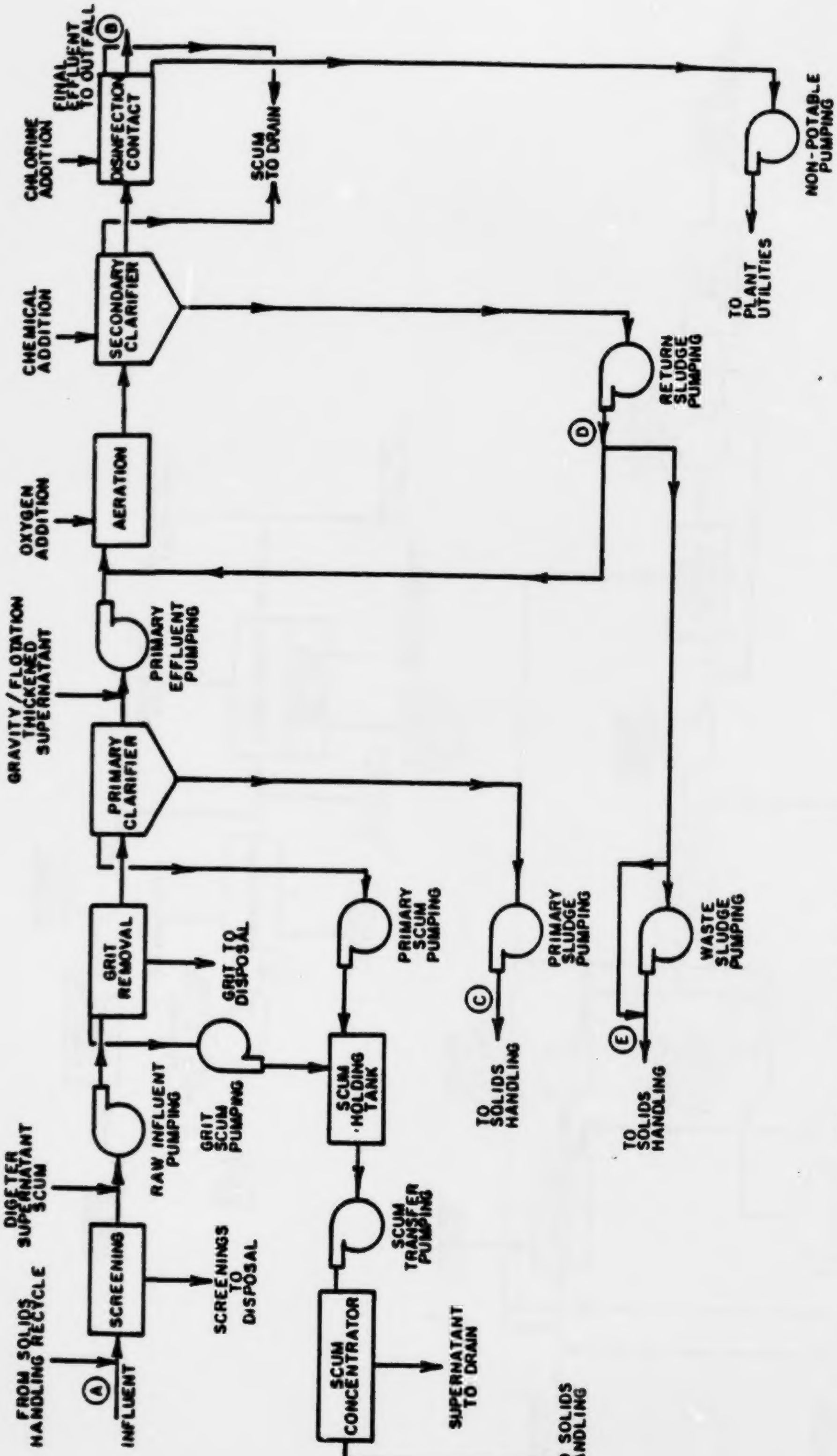

FROM SOLIDS HANDLING RECYCLE
INFLUENT
A
SCREENING
SCREENINGS TO DISPOSAL
DIGETER SUPERNATANT SCUM
RAW INFLUENT PUMPING
GRIT SCUM PUMPING
GRIT REMOVAL
GRIT TO DISPOSAL
SCUM HOLDING TANK
SCUM TRANSFER PUMPING
SCUM CONCENTRATOR
SUPERNATANT TO DRAIN
TO SOLIDS HANDLING
PRIMARY SCUM PUMPING
PRIMARY CLARIFIER
PRIMARY SLUDGE PUMPING
C
TO SOLIDS HANDLING
GRAVITY/FLOTATION THICKENED SUPERNATANT
PRIMARY EFFLUENT PUMPING
OXYGEN ADDITION
AERATION
CHEMICAL ADDITION
SECONDARY CLARIFIER
RETURN SLUDGE PUMPING
D
WASTE SLUDGE PUMPING
E
TO SOLIDS HANDLING
CHLORINE ADDITION
DISINFECTION CONTACT
SCUM TO DRAIN
FINAL EFFLUENT TO OUTFALL
B
NON-POTABLE PUMPING
TO PLANT UTILITIES

Figure 3-2. Liquid Process Flow Diagram for Site SSI-A.

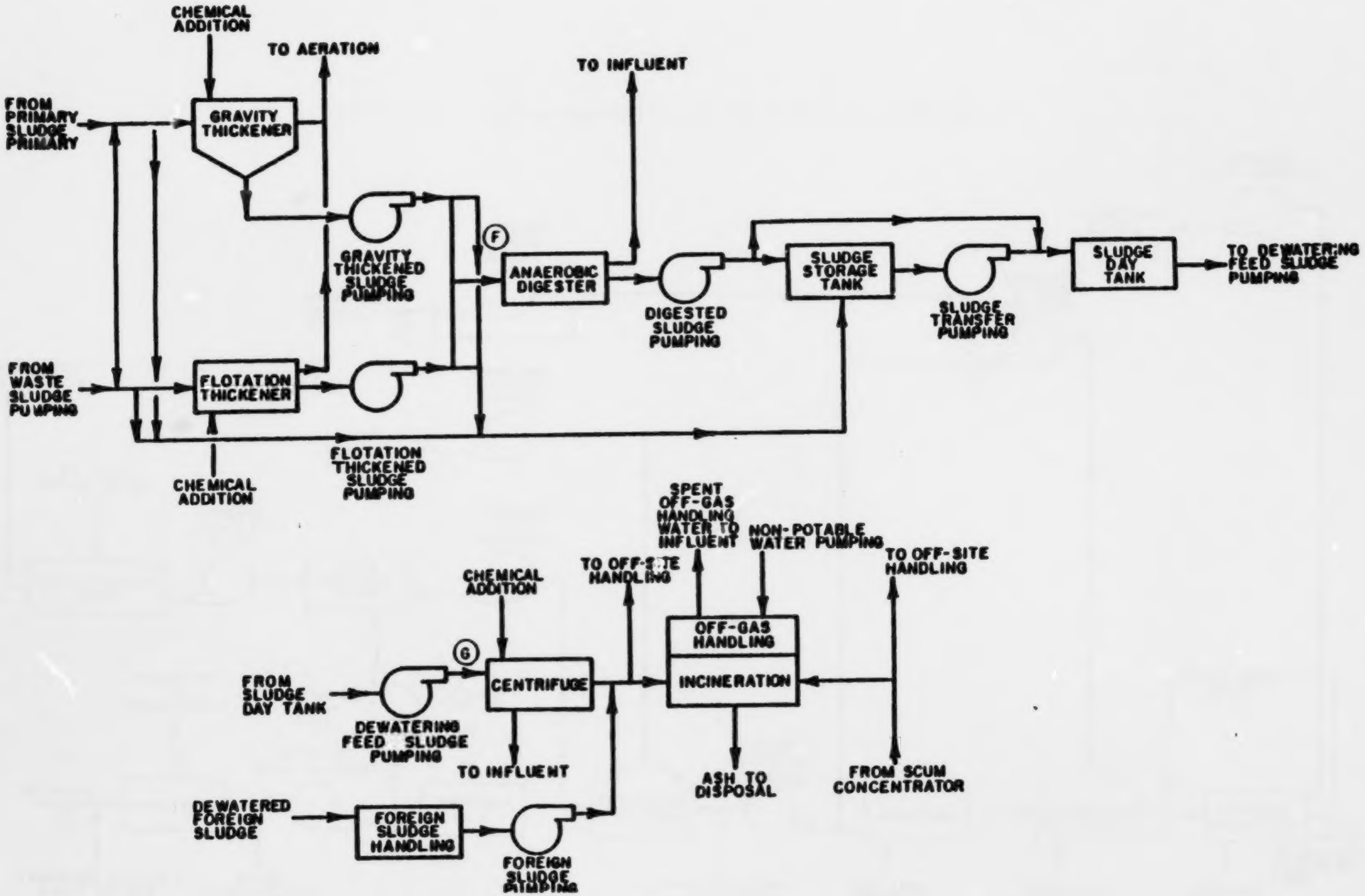

CHEMICAL ADDITION
TO AERATION
TO INFLUENT
FROM PRIMARY SLUDGE PRIMARY
GRAVITY THICKENER
GRAVITY THICKENED SLUDGE PUMPING
F
ANAEROBIC DIGESTER
DIGESTED SLUDGE PUMPING
SLUDGE STORAGE TANK
SLUDGE TRANSFER PUMPING
SLUDGE DAY TANK
TO DEWATERING FEED SLUDGE PUMPING
FROM WASTE SLUDGE PUMPING
FLOTATION THICKENER
CHEMICAL ADDITION
FLOTATION THICKENED SLUDGE PUMPING
SPENT OFF-GAS HANDLING WATER TO INFLUENT
NON-POTABLE WATER PUMPING
TO OFF-SITE HANDLING
CHEMICAL ADDITION
TO OFF-SITE HANDLING
G
FROM SLUDGE DAY TANK
DEWATERING FEED SLUDGE PUMPING
CENTRIFUGE
TO INFLUENT
OFF-GAS HANDLING
INCINERATION
ASH TO DISPOSAL
FROM SCUM CONCENTRATOR
DEWATERED FOREIGN SLUDGE
FOREIGN SLUDGE HANDLING
FOREIGN SLUDGE PUMPING

Figure 3-3. Solids Processing Flow Diagram for Site SSI-A.

Digested or undigested sludge is sent from the storage tank to the final dewatering system. The sludge is dewatered using aliphatic polyelectrolyte polymer addition followed by centrifugation. Dewatered sludge is transferred by belt conveyor from the centrifuges to the incinerators. Dewatered digested sludge typically has a solids content of approximately 16 to 17 weight percent, and dewatered undigested sludge typically has a solids content of 19 to 23 weight percent. During the dioxin/furan tests, only undigested sludge was burned in the incinerator.

3.2 INCINERATOR DESCRIPTION

The plant operates two multiple hearth sewage sludge incinerators (designated by the plant as units No. 1 and No 2). The incinerators are not operated simultaneously. Typically, one of the incinerators burns sludge for 2 to 3 weeks, followed by a 7 to 10 day period of no burning. The alternate incinerator is generally used when the next "burn cycle" begins.

The No. 1 unit was tested in this program. It is a six-hearth incinerator designed by Envirotech with a current capacity of 3,400 kg/hr (7,500 lb/hr) wet sludge. A schematic diagram of the incinerator and wet scrubber system is shown in Figure 3-4. The solids content of the dewatered sludge burned in the incinerator ranges from 16 to 23 weight percent and the volatiles content of the solids is typically 70 percent by weight. The heating value and moisture content of the sludge does not allow for autogenous burning. Gas produced by the anaerobic digester, and No. 2 fuel oil are burned in the incinerator as supplemental fuels. The auxiliary fuel firing rates are adjusted to maintain the desired temperature profile within the incinerator.

The target temperature for the gas leaving the upper hearth (Hearth No. 1) is 380°C (720°F); the range of temperatures typically measured for the gas leaving the upper hearth is 315° to 480°C (600° to 900°F). Excursions as high as 760°C (1,400°F) are possible when the combustion pattern in the incinerator is out of control or when the incinerator is being "burned out" of sludge. This occurs when the sludge feed to the incinerator is stopped prior to a shutdown. According to plant personnel, a six-hearth sewage sludge incinerator is a tight design that requires constant operator attention to control the location of the sludge combustion inside the

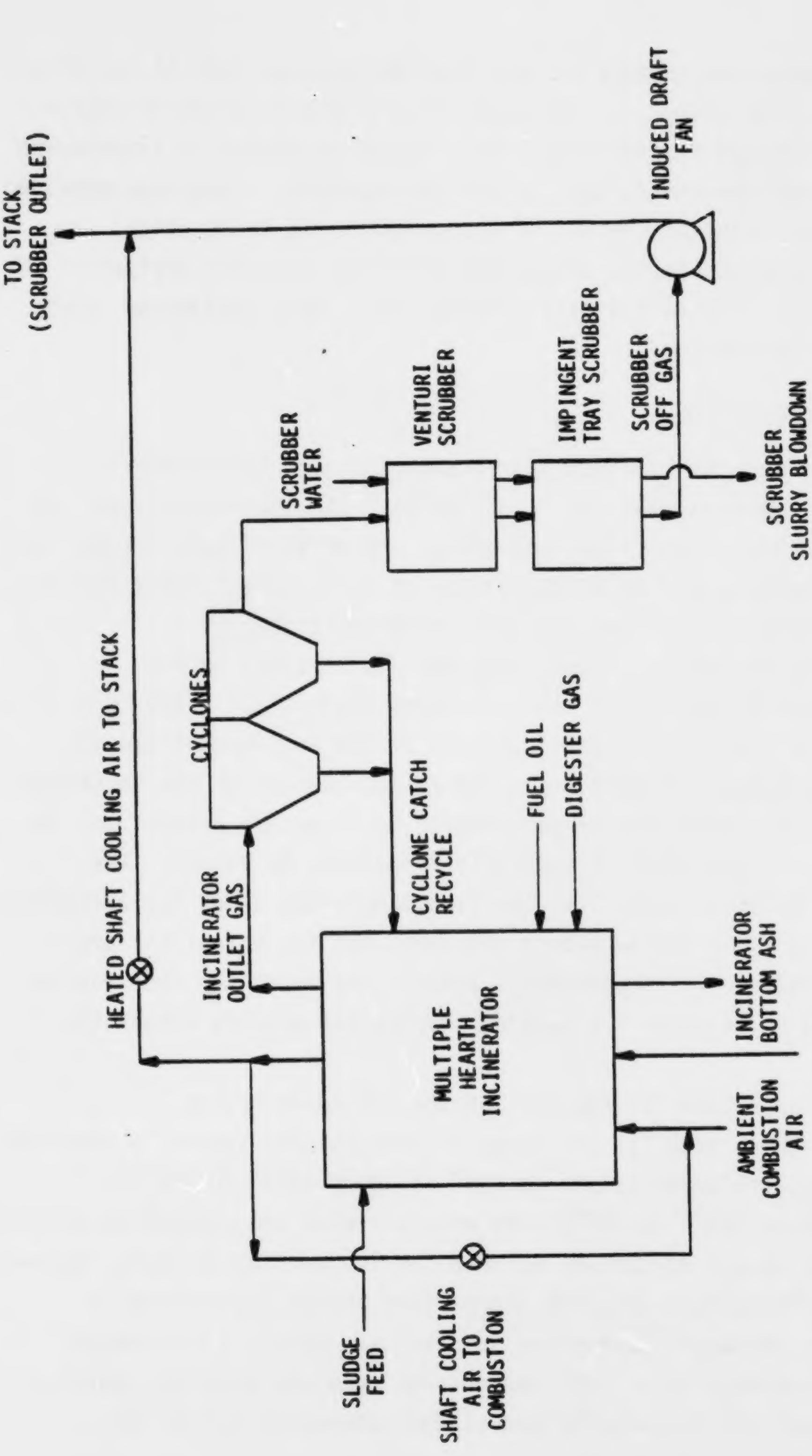

TO STACK
(SCRUBBER OUTLET)
HEATED SHAFT COOLING AIR TO STACK
INDUCED DRAFT
FAN
SCRUBBER
WATER
VENTURI
SCRUBBER
IMPINGENT
TRAY SCRUBBER
SCRUBBER
OFF GAS
SCRUBBER
SLURRY BLOWDOWN
CYCLONES
INCINERATOR
OUTLET GAS
CYCLONE CATCH
RECYCLE
FUEL OIL
DIGESTER GAS
MULTIPLE
HEARTH
INCINERATOR
INCINERATOR
BOTTOM ASH
SHAFT
COOLING
AIR
AMBIENT
COMBUSTION
AIR
SLUDGE
FEED
SHAFT COOLING
AIR TO
COMBUSTION

Figure 3-4. Detailed Schematic Diagram of the Sewage Sludge Incinerator/Wet Scrubber System.

incinerator. Most temperature excursions are due to inadequate operator attention. The sludge combustion zone is normally maintained on Hearth No. 3.

Combustion air fed to the incinerator can be either at ambient temperature or a preheated temeprature, depending on operator preference. The preheated combustion air is supplied by recycling a portion of the heated air leaving the rabble arm shaft cooling air system. The design flow of the shaft cooling air is approximately 140 scmm (5,000 scfm). During the dioxin tests, all shaft cooling air was vented out the stack. All combustion air fed to the incinerator was ambient air supplied by a forced draft fan. The total amount of combustion air fed to the incinerator varies with the incinerator feed rate, opacity limitations, furnace draft, and other operating parameters. The oxygen content of the flue gas at the incinerator outlet (i.e., furnace breeching) is typically 13 to 17 percent O_2 (wet basis) as measured by plant monitoring equipment. Lower excess air levels are not achievable due to formation of significant opacity. The plant normally maintains an in-situ flue gas oxygen analyzer at the furnace breeching, but this instrument was not operating during the test program. Furnace draft at the breeching outlet is maintained at approximately -0.04 kPa (-0.15 inches H_2O).

Bottom ash produced by the incinerator is screw conveyed out of the incinerator into a bucket elevator, which carries the ash about 40 feet vertically. The ash is then screw conveyed to a large hopper that is used for intermediate storage prior to disposal. Design specifcations for the incinerator indicate that approximately 250 kg/hr (550 lb/hr) of bottom ash are produced when the sludge feed rate to the incinerator is 3,400 kg/hr (7,500 lb/hr) wet sludge.

3.3 EMISSION CONTROL SYSTEM DESCRIPTION

Emissions from incinerator SSI-A are controlled by two cyclones in series with a water quench unit, a venturi scrubber, and an impingement tray scrubber. Testing by plant personnel indicates that the cyclones capture about 3.5 kg of particulate matter per 1,000 kg of dry solids fed to the incinerator. The particulate matter captured by the cyclones is screw conveyed directly back into the incinerator.

Exhaust gases from the cyclones pass through a water spray cooling section in the ductwork and are then sent to the venturi and impingement tray scrubbers. The spray cooling water, venturi scrubber water, and impingement tray scrubber water consist of sewage treatment plant effluent that is used once in the scrubber system and then sent back to the treatment plant after use. The scrubber system uses a total of approximately 4,500 m^3 (1.2 million gallons) of treatment plant effluent per day. Approximately two-thirds of this water is added to the impingement tray scrubber, and most of the remainder is added to the venturi scrubber. The spray cooler preceding the venturi scrubber and another spray cooler preceding the impingement tray scrubber use about 7 percent of the total scrubber system water. The overall ratio of scrubber water to incinerator exhaust gas (i.e., liquid-to-gas ratio) is approximately 0.025 m^3 water/dscm exhaust gas (0.2 gal/dscf). Pressure drops across the venturi and impingement tray scrubbers are typically 28 mm Hg and 9 mm Hg (15 inches H_2O and 5 inches H_2O), respectively. Exhaust gas exits the scrubber system at a temperature of approximately 27°C (80°F). The exhaust gas is pulled through an induced draft fan, combined with any shaft cooling air that is not used as preheated combustion air, and sent out the stack. The current rated capacity of the induced draft fan is 190 acmm at 54°C and 84 mm Hg (6,800 acfm at 130°F and 45 inches H_2O).

3.4 PROCESS DATA MONITORED BY THE PLANT

Process data monitored regularly by the plant include data on both the incinerator and the venturi/impingement tray scrubber system. The incinerator operating data include wet sludge feed rate (lb/hr), flue gas oxygen content at the breeching outlet (percent O_2 wet), furnace draft at the breeching outlet (inches H_2O), individual hearth temperatures (°F), and shaft cooling air outlet temperature (°F). The scrubber operating data include venturi scrubber and impingement tray scrubber pressure drops (inches H_2O), venturi scrubber inlet gas temperature (°F), and induced draft (ID) fan inlet temperature (°F). Because of the proximity of the ID fan to the impingement tray scrubber outlet, the ID fan inlet temepraturé is essentially the same as the impingement tray scrubber outlet temperature.

In addition to the regularly monitored operating parameters, plant personnel perform daily analyses of the sludge fed to the incinerator. The percent solids and the percent volatile solids are measured on a daily basis. The sample analyzed is a composite of 24 hourly samples taken off the sludge feed belt leading to the incinerator. Each hourly sample consists of about 0.2 kg (0.5 lb) of sludge.

4.0 TEST DESCRIPTION

This section describes the field sampling, process monitoring, and analytical activities that were performed for Site SSI-A. The purpose of this section is to provide sufficient descriptive information about the test so that the test data presented in Section 5.0 can be easily understood. Testing details (specific sampling locations and procedures) are presented in Section 6.0.

This section is divided into three parts. Section 4.1 summarizes field sampling activities, Section 4.2 summarizes process monitoring activities, and Section 4.3 summarizes analytical activities performed during the test program.

4.1 FIELD SAMPLING

Table 4-1 shows the source sampling and analysis matrix for Site SSI-A. Three sets of dioxin/furan emissions tests were performed on consecutive days at the scrubber outlet and scrubber inlet (i.e., incinerator outlet) sampling locations. These locations are shown schematically in Figure 4-1 as Points A and B, respectively. Dioxin/furan sampling was based on the Modified Method 5 (MM5) sampling protocol developed by the American Society of Mechanical Engineers (ASME) for measuring emissions of chlorinated organic compounds. Sampling was performed isokinetically for a minimum of 4 hours at each location.

Continous emission monitoring (CEM) of O_2, CO, CO_2, SO_2, NO_x, and total hydrocarbons (THC) was performed during the three MM5 test runs. These data were obtained to assess variations in combustion during the sampling periods. Instantaneous concentration values for each species monitored were determined every five minutes by the CEM system.

Ambient air sampling was performed at the point of combustion air intake using an ambient XAD sampling train. Two co-located trains were operated simultaneously during the three MM5 runs such that two identical integrated ambient air samples were obtained. One of the samples was obtained for potential dioxin/furan analyses, and the other was obtained for potential dioxin/furan precursor analyses. The intent of the ambient air sampling was

TABLE 4-1. SOURCE SAMPLING AND ANALYSIS MATRIX - PLANT SSI-A

Sample Location	Sample Type or Parameter	Sampling Method	Analysis Method	Number of Samples or Frequency
1. Scrubber outlet exhaust stack (Point H, Fig. 6-1)	Dioxin/furan emissions	Modified EPA Method 5 (MM5)	Gas chromatograph/mass spectrometer	Three test runs; one per test day.
	Volumetric flow	EPA Method 2	Not Applicable	Once per MM5 test run.
	Molecular weight	EPA Method 3	Gas chromatograph/thermal conductivity detector	Two integrated bag samples per MM5 test run.
	Moisture	EPA Method 4	Gravimetric balance	Once per MM5 test run.
2. Scrubber inlet/ incinerator outlet (Point C, Fig. 6-1)	Dioxin/furan emissions	Modified EPA Method 5 (MM5)	Gas chromatograph/mass spectrometer	Three test runs; one per test day.
	Volumetric flow	EPA Method 2	Not Applicable	Once per MM5 test run.
	Molecular weight	EPA Method 3	Gas chromatograph/thermal conductivity detector	Two integrated bag samples per MM5 test run.
	Moisture	EPA Method 4	Gravimetric balance	Once per MM5 test run.
	CO/CO_2	In-stack filter probe and heat-traced Teflon sample	Non-dispersive infrared analyzer	Continuously during MM5 test run.
	O_2	Same as CO/CO_2	Paramagnetic analyzer	Continuously during MM5 test run.
	NO_x	Same as CO/CO_2	Chemiluminescent analyzer	Continuously during MM5 test run.
	Total Hydrocarbons (THC)	Same as CO/CO_2	Flame ionization analyzer	Continuously during MM5 test run.
3. Ambient air	Dioxin/furan and precursor concentrations	Ambient air/XAD resin train	Gas chromatograph/mass spectrometer	Duplicate integrated samples taken during the three MM5 test runs.
4. Sewage sludge feed belt	Sewage sludge for dioxin/furan and precursor content	Grab samples	Gas chromatograph/mass spectrometer	Duplicate samples of hourly sample composite for each MM5 test run.
5. Bottom ash screw conveyor	Bottom ash for dioxin/furan content	Grab samples	Gas chromatograph/mass spectrometer	One sample of hourly sample composite for each MM5 test run.
6. Scrubber blowdown	Scrubber blowdown for dioxin/furan content	Tap valve sample	Gas chromatograph/mass spectrometer	One sample of hourly sample composite for each MM5 test run.
7. Fuel oil line	Fuel oil for dioxin/furan precursor content	Tap valve sample	Gas chromatograph/mass spectrometer	Duplicate samples of hourly sample composite for each MM5 test run.
8. Plant property	Solids for dioxin/furan content	Grab samples	Gas chromatograph/mass spectrometer	One composite of 10 soil samples

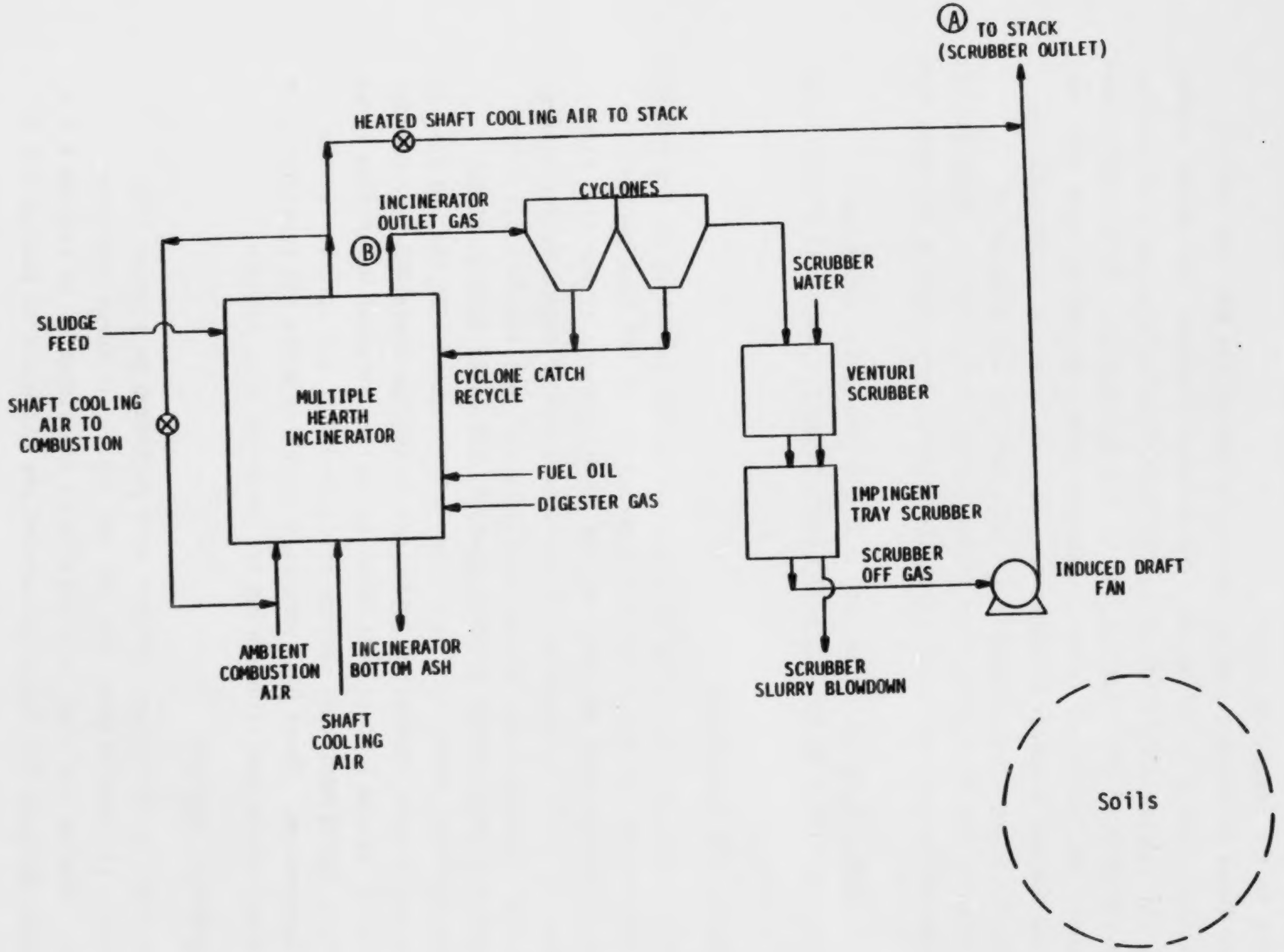

Ⓐ TO STACK
(SCRUBBER OUTLET)
HEATED SHAFT COOLING AIR TO STACK
INCINERATOR OUTLET GAS
Ⓑ
CYCLONES
SCRUBBER WATER
SLUDGE FEED
SHAFT COOLING AIR TO COMBUSTION
MULTIPLE HEARTH INCINERATOR
CYCLONE CATCH RECYCLE
VENTURI SCRUBBER
FUEL OIL
DIGESTER GAS
IMPINGENT TRAY SCRUBBER
SCRUBBER OFF GAS
INDUCED DRAFT FAN
AMBIENT COMBUSTION AIR
INCINERATOR BOTTOM ASH
SCRUBBER SLURRY BLOWDOWN
SHAFT COOLING AIR
Soils

Figure 4-1. Sample Point Diagram for the Sewage Sludge Incinerator/Wet Scrubber System.

to determine the presence or absence of dioxin/furan and dioxin/furan precursors in the combustion air.

Four types of process samples were taken during the MM5 test periods: sewage sludge, fuel oil, bottom ash, and scrubber blowdown. The sewage sludge and fuel oil samples were taken to characterize dioxin/furan and dioxin/furan precusor contents of the materials fed to the incinerator. These samples were taken hourly and individual composite samples were prepared for each test run. The bottom ash and scrubber blowdown samples were taken to investigate the potential for using these materials as indicators of the presence of dioxin/furan in the flue gases from sewage sludge incinerators. These samples were taken hourly and individual composite samples were prepared for each test run.

Soil samples were collected into a single composite, which was transferred to Tier 7 of the National Dioxin Study for potential dioxin/furan analysis.

4.2 PROCESS DATA COLLECTION

Process data were collected to characterize the operation of the multiple hearth incinerator and wet scrubber system during the MM5 test periods. Incinerator process data obtained include hourly average sludge feed rates, continuous strip chart recordings of individual hearth temepratures, hourly furnace draft measurements, average auxiliary fuel oil and fuel gas firing rates, daily average sludge moisture content, and daily average sludge volatiles content. These data were used in conjunction with the CEM data to evaluate and compare combustion conditions during the three MM5 test periods.

Scrubber system process data obtained include scrubber water flow rates, venturi and impingement tray section pressure drops, and scrubber system outlet temperature. These data were used to characterize the consistency of the scrubber system operation during the three MM5 test periods.

4.3 LABORATORY ANALYSES

Two types of laboratory analyses were performed on samples from Site SSI-A: (1) dioxin/furan analyses and (2) dioxin/furan precursor analyses. Samples analyzed for dioxin/furan are discussed in Section 4.3.1, and samples analyzed for dioxin precursors are discussed in Section 4.3.2.

4.3.1 Dioxin/Furan Analyses

All dioxin/furan analyses for Site SSI-A samples were performed by EMSL-RTP and ECL-Bay St. Louis laboratories, two of the three EPA laboratories known collectively as Troika.

Dioxin/furan analyses were performed by high resolution gas chromatography/mass spectroscopy. The 2378-TCDD isomer and the tetra- through octa-chlorinated homologues were quantified. The 2378-TCDF isomer was not quantified at this test site.

4.3.2 Dioxin/Furan Precursor Analyses

Dioxin/furan precursor analyses of sludge feed samples were performed by Radian. The specific dioxin/furan precursors analyzed for included chlorophenols, chlorobenzenes, and PCB's. Total chlorine analyses were performed by Research Triangle Institute (RTI) on sludge feed and fuel oil samples.

5.0 TEST RESULTS

The results of the Tier 4 dioxin/furan emissions test of incinerator SSI-A are presented in this section. It should be noted that the individual test runs are designated as Runs 9-11. Eight tests (Runs 1-8) were performed on incinerator SSI-A for another EPA program prior to the Tier 4 tests. The original field numbering of the test runs was retained.

Process data obtained during the test runs are presented in Section 5.1, and results of the continuous monitoring of O_2, CO, CO_2, NO_x, SO_2, and THC are presented in Section 5.2. Flue gas parameter data are presented in Section 5.3. The dioxin/furan emissions data are contained in Section 5.4. Results of all other analyses are presented in Sections 5.5 through 5.7.

5.1 PROCESS DATA

Process data were obtained to document incinerator and scrubber operation during the test runs. The incinerator data are summarized in Section 5.1.1., and the scrubber data are summarized in Section 5.1.2.

5.1.1 Incinerator Operating Data

Operating data for multiple hearth sewage sludge incincerator SSI-A during the three MM5 test runs are shown in Table 5-1. The data show that, in general, the incinerator was operated similarly during the runs. MM5 sampling was performed continuously during Runs 09 and 10 except during sample port changes. Sampling during Run 11 was interrupted by a process upset period that lasted for approximately one hour. During the process upset, incinerator exhaust gas was observed coming out of the emergency scrubber bypass stack on top of the incinerator. Sampling was interrupted until this condition ended. There were no indications in the control room of unusual incinerator or scrubber operating conditions other than a lower than normal temperature on Hearth 4.

The mean wet sludge feed rate to the incinerator during the tests was approximately 1,900 kg/hr (4,200 lb/hr), with a maximum deviation from the mean of about 5 percent for any run. The dry sludge feed rate variability was

TABLE 5-1. MEAN INCINERATOR OPERATING PARAMETERS DURING DIOXIN/FURAN TESTS AT SITE SSI-A[a]

Parameter	Run 09	Run 10	Run 11	Average
1. Wet Sludge Feed Rate (lb/hr)[b]	4,050	4,360	4,043	4,151
2. Dry Sludge Feed Rate (lb/hr)[b]	774	950	906	877
3. Percent Solids of Wet Sludge (wt%)	19.1	21.8	22.4	21.1
4. Percent Volatiles of Dry Sludge	68	68	72	69
5. Percent O_2 at Breeching (dry, vol%)	12.1	11.9	11.7	11.9
6. Fuel Gas Fired (10^3 cu ft/hr)[c]	2.4	3.4	1.8	2.5
7. Fuel Oil Fired (gal/hr)[d]	9.3	21.3	9.1	13.2

[a] Data shown in units used by the host plant.

[b] To convert from lb/hr to kg/hr, multiply value in lb/hr by 0.454.

[c] To convert from cu ft/hr to cu meter/hr, multiply value in cu ft/hr by 0.0283.

slightly higher (± 12 percent between runs), because of the gradual increase in sludge solids content from 19.1 weight percent to 22.4 weight percent during the tests. According to plant personnel, the sludge solids content increased because the ratio of primary sludge to secondary sludge received by the solids handling department was somewhat higher at the end of the test than it was at the beginning. Primary sludge dewaters more readily than secondary sludge and therefore tends to have a higher solids content.

The sludge feed rates during the tests were about 30 percent lower than usual for this incinerator. A shortage of sludge at the plant made it necessary to reduce the sludge feed rate so that enough sludge would be available to complete the tests on schedule. The feed rate during the test periods was the maximum possible rate under this constraint. After each test, the feed rate to the incinerator was first reduced and then stopped to conserve sludge. Hearth temperatures were maintained overnight by firing fuel gas and No. 2 oil. Sludge feed to the incinerator was resumed at least 3 to 4 hours prior to the beginning of each test run. This is not expected to have significantly affected the dioxin emission results since the target temperature of the main combustion hearth (Hearth 3) and the overall excess air conditions were typical of normal conditions for this incinerator.

Mean temperatures for each of the incinerator hearths during the MM5 runs are shown in Table 5-2. Figures 5-1, 5-2, and 5-3 show the continuous strip chart recordings of these temperatures. The identification code for the individual curves is listed in Table 5-3. The data indicate that there were definite between-run differences in the vertical temperature profile inside the incinerator.

The main sludge burn hearth during all three test runs was Hearth 3, as evidenced by the highest overall mean temperature (780°C or 1,400°F) and by visual observation of the flame pattern through observation ports. The mean temperature of Hearth 3 varied no more than 5 percent between any two runs, indicating that the main sludge burn zone was operated similarly during the three test runs. Figures 5-1 through 5-3 indicates that within-run variations in Hearth 3 temperatures were also small.

The most signficant operating differences observed during the test runs were the temperature histories of Hearth 4, which is the hearth below the main

TABLE 5-2. MEAN HEARTH TEMPERATURES DURING DIOXIN/FURAN TESTS AT SITE SSI-A[a,b]

Hearth Number[c]	Run 09	Run 10	Run 11	Average
1	714	778	790	761
2	1,184	1,153	1,141	1,159
3[d]	1,406	1,470	1,437	1,438
4	979	1,423	1,058	1,153
5	359	627	480	489
6	115	118	148	127

[a] Data shown in units used by host plant (°F). To convert from °F to °C, use the formula °C = (°F -32)/1.8.

[b] Strip chart data recording continuous hearth temperatures are contained in Figure 5-1, 5-2, and 5-3.

[c] Hearths are designated according to plant nomenclature. Hearth No. 1 is the top hearth, hearth No. 6 is the bottom hearth. Other hearths are numbered sequentially from top to bottom.

[d] The majority of sludge combustion occurred on Hearth 3 during each of the test runs.

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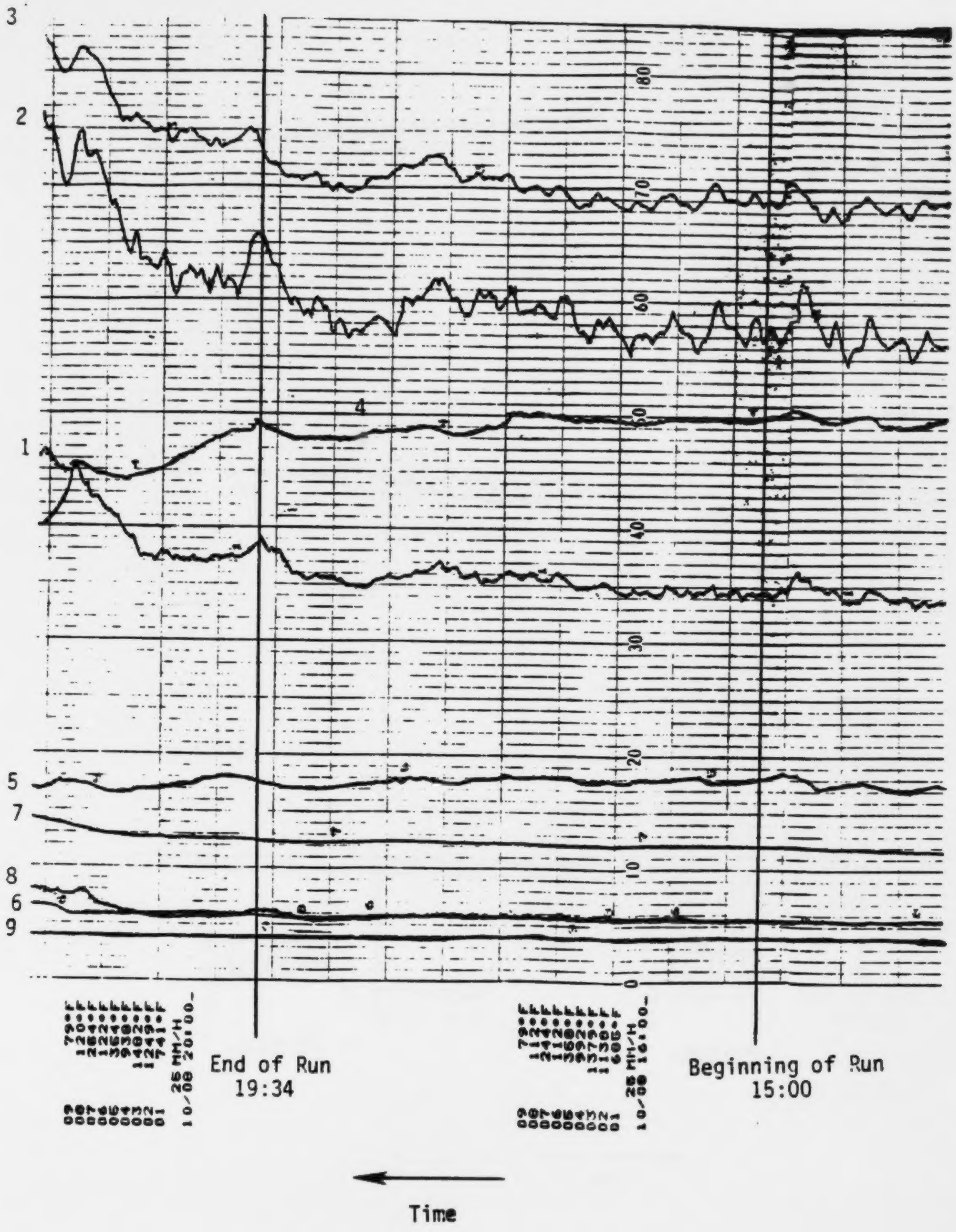

Figure 5-1. Hearth Temperature Histories, Run 09.

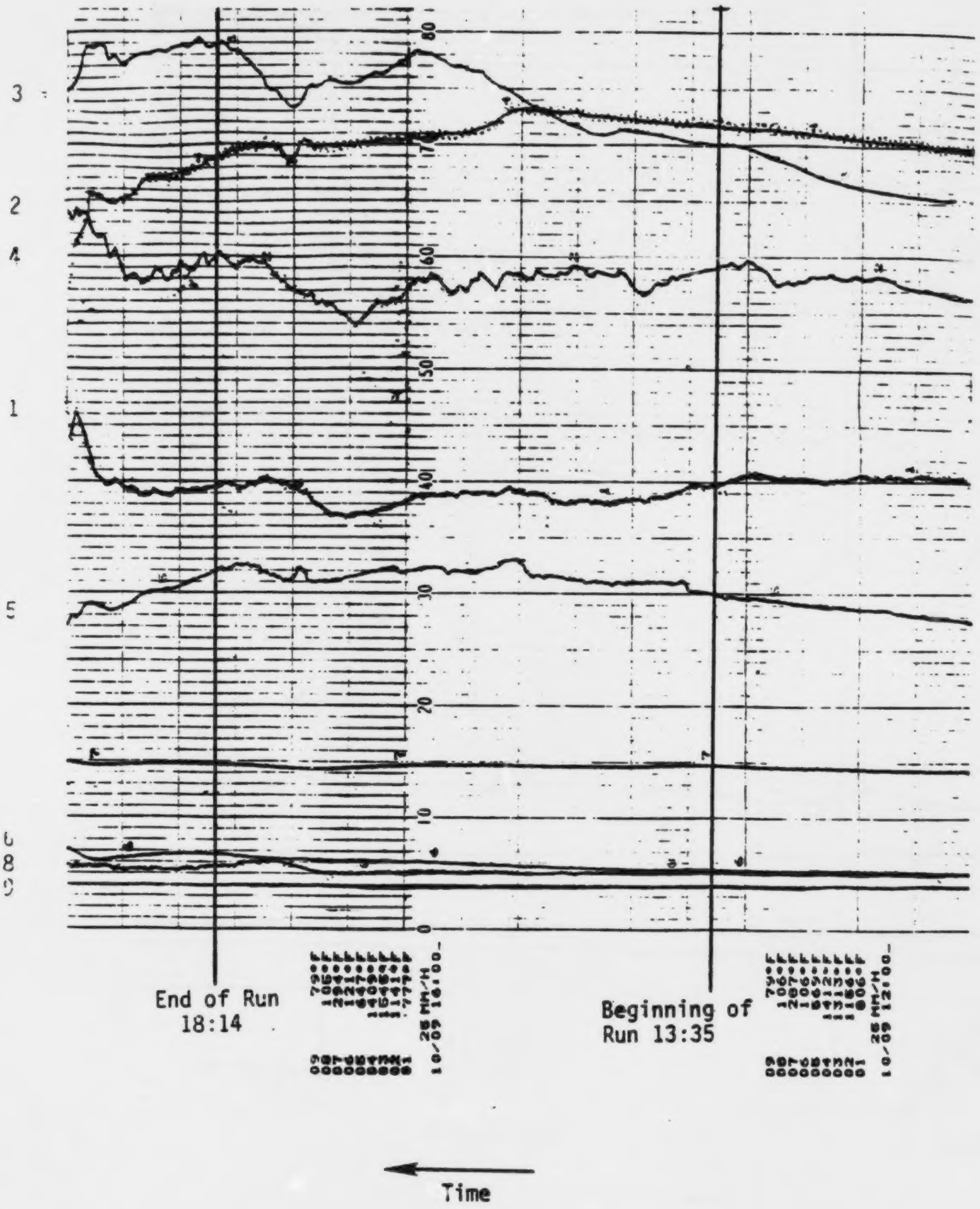

Figure 5-2. Hearth Temperature Histories, Run 10.

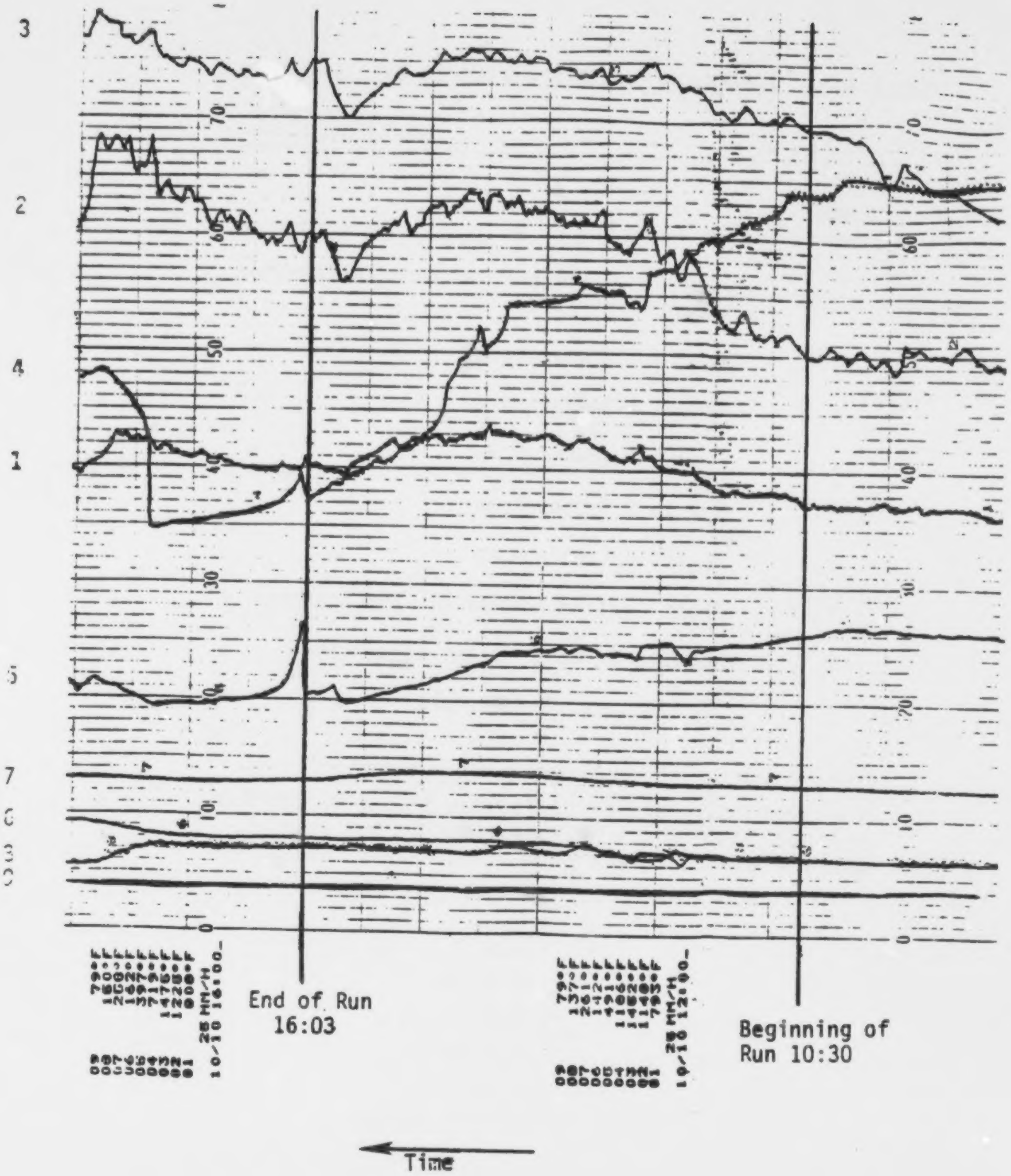

Figure 5-3. Hearth Temperature Histories, Run 11.

TABLE 5-3. TEMPERATURE CODE FOR FIGURES 5-1, 5-2, and 5-3[a]

Code Number	Temperature
1	Outlet Gas Temperature from Incinerator (Hearth 1)
2	Hearth 2 Temperature
3	Hearth 3 Temperature
4	Hearth 4 Temperature
5	Hearth 5 Temperature
6	Hearth 6 Temperature
7	Shaft Cooling Air Outlet Temperature
8	Venturi Scrubber Inlet Temperature
9	ID Fan Inlet Temperature

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[a] The temperature scales of Figures 5-1, 5-2, and 5-3 are indicated by the instantaneous values printed every 4 hours at the bottom of the strip charts.

sludge burn zone. The mean temperature of Hearth 4 varied as much as 30 percent between runs, ranging from 525°C (980°F) in Run 09 to 770°C (1,420°F) in Run 10. The most significant within-run variability for any parameter was also exhibited by the Hearth 4 temperature. In Run 11 (Figure 5-3) the temperature of Hearth 4 varied from approximately 700°C (1290°F) to 390°C (730°F) during the 7 hour period that MM5 sampling was performed. Plant personnel indicated that the sludge burn zone during Run 11 was tending to move up onto Hearth 2, thereby cooling off the lower hearths of the incinerator. Attempts were made to maintain the temperature of Hearth 4 at a more consistent level, but the operators were unsuccessful in doing so. Plant personnel indicated that although significant changes in the temperature of Hearth 4 occurred during Run 11, this was not considered extremely unusual. The run was accepted as a valid sampling run.

In summary, the incinerator was operated similarly during the three MM5 runs in terms of sludge feed rate, sludge characteristics and primary sludge burn temperature. Some between-run differences were observed in the individual hearth temperatures below the primary sludge burn zone, particularly for Hearth 4. Run 11 showed the greatest within-run variability of hearth temperature.

5.1.2 Scrubber Operating Data

Mean scrubber system operating data during the MM5 test runs are summarized in Table 5-4. The pressure drop data across the venturi scrubber and the impingement tray scrubber showed that the scrubber system was operated steadily during the tests. The mean pressure drops across the venturi and impingement tray scrubbers were 4.6 kPa (18.5 inches H_2O) and 1.3 kPa (5.3 inches H_2O), respectively. Scrubber water flows were estimated by plant personnel based on previous measurements. Valve settings on the scrubber water flow were not adjusted during the tests. The total estimated scrubber water flow of 3.1 cu meter/min (807 gpm) was distributed as follows: pre-cooler, 0.1 cu meter/min (33 gpm); venturi scrubber, 0.9 cu meter/min (247 gpm); impingement tray scrubber, 0.1 cu meter/min (27 gpm); and impingement tray scrubber trays, 1.9 cu meter/min (500 gpm). The calculated liquid-to-gas ratio was 0.032 cu meter/dscm (0.24 gal/dscf). The mean scrubber outlet temperature was 26°C (79°F) for all three runs.

TABLE 5-4. MEAN SCRUBBER OPERATING PARAMETERS DURING DIOXIN/FURAN TESTS AT SITE SSI-A[a]

Parameter	Run 09	Run 10	Run 11	Average
1. Venturi ΔP	19.0	17.1	19.3	18.5
2. Impinger ΔP	5.5	5.5	4.8	5.3
3. Scrubber System Water Flow (gpm)[c]	807	807	807	807
4. Scrubber Exhaust Gas Temperature (°F)[d]	79	79	79	79

[a] Data shown in units used by host plant.

[b] To convert from in H_2O to kPa, multiply value in in H_2O by 0.249.

[c] To convert from gpm to cu meter/min, mutiply value in gpm by 0.00379.

[d] To convert from °F to °C, use the formula °C = (°F - 32)/1.8.

5.2 CONTINUOUS MONITORING DATA

Mean values of the continuously monitored combustion gases (O_2, CO, CO_2, SO_2, NO_x, THC) are shown for each run in Table 5-5. The data show that most of the runs have similar mean concentration values for individual gases. The overall mean values for the three test runs are as follows: oxygen, 11.9 percent by volume (dry); carbon monoxide, 1190 ppmv (dry); carbon dioxide, 14.0 percent by volume (dry); sulfur oxides, 525 ppmv (dry); nitrogen oxides, 162 ppmv (dry); and total hydrocarbons, 73 ppmv as propane (wet). The only combustion gas with a mean value that varied signficiantly between runs was THC. The measured THC concentration for Run 09 (133 ppmv) was approximately three times higher than that for Run 10 (44pmv) or Run 11 (41 ppmv). No explanation for this difference is apparent from the process data.

Five-minute average values for the continuously monitored combustion gases are tabulated in Appendix A-2 and are shown graphically as functions of time in Figure 5-4 through 5-9. These graphs show that although the mean concentration values of the monitored combustion gases were similar for the three runs, the instantaneous behavior of these concentrations varied. In particular, the process problems during Run 11 that were discussed in Section 5.1 are reflected in the varying oxygen concentration profile in Figure 5-4. However, these process conditions did not seem to have a signficant impact on either the carbon monoxide or total hydrocarbon profiles for Run 11. Reductions in the flue gas oxygen content that occurred in Run 09 and Run 10 corresponded with noticeable short term increases in carbon monoxide and/or total hydrocarbon formation.

5.3 FLUE GAS PARAMETER DATA

This section summarizes flue gas parameter data measured at the incinerator outlet and the scrubber outlet exhaust stack. The flue gas parameters measured included temperature, moisture content, volumetric flow rate, and oxygen concentration. Values for the two sampling locations are considerably different due to (1) the gas cooling/moisture condensation associated with the wet scrubber and (2) the dilution associated with the shaft cooling air stream.

TABLE 5-5. MEAN VALUES OF CONTINUOUSLY MONITORED COMBUSTION GASES DURING DIOXIN/FURAN TESTS AT SITE SSI-A.

Parameter[a]	Run 09	Run 10	Run 11	Overall Mean
O_2 (% vol)	12.1	11.9	11.7	11.9
CO (ppmv)	1403	1047	1120	1190
CO_2 (% vol)	12.4	13.7	15.8	14.0
SO_2 (ppmv)	496	482	597	525
NO_x (ppmv)	109	202	175	162
THC (ppmv)[b]	133	44	41	73

[a] All concentration values expressed on a dry volume basis for total hydrocarbons (THC), which is expressed on a wet volume basis.

[b] Total hydrocarbon data are expressed in units of ppmv (wet) as propane.

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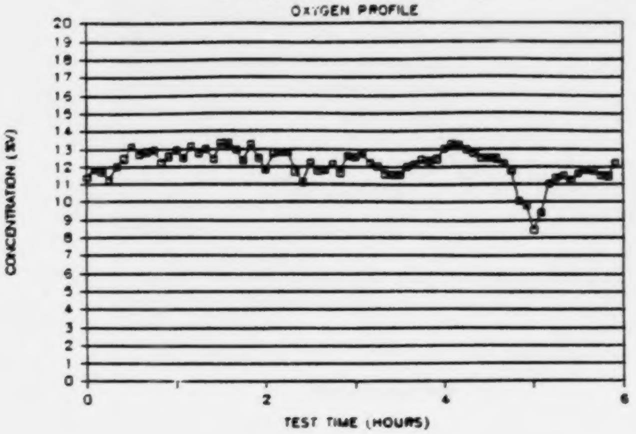
SITE 01 – TEST 9
OXYGEN PROFILE



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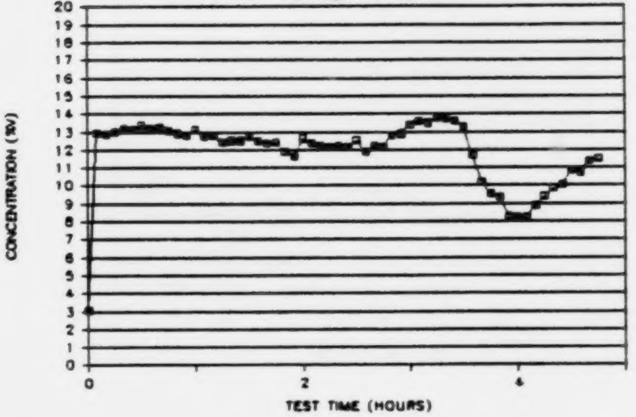
OXYGEN PROFILE



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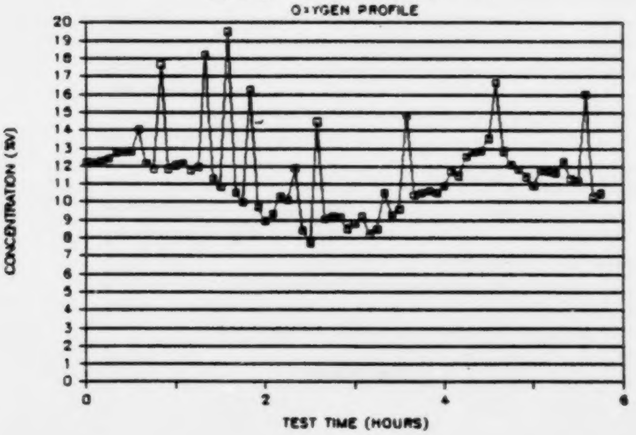
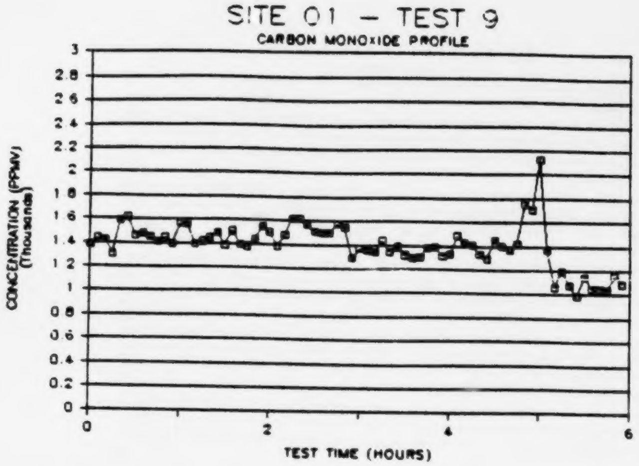
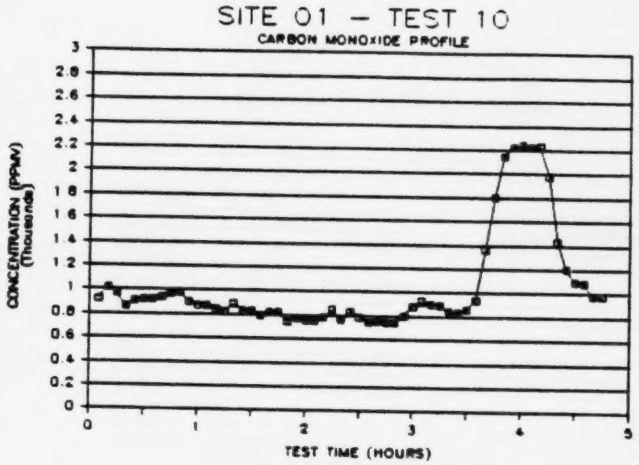
OXYGEN PROFILE




SITE 01 – TEST 9
CARBON MONOXIDE PROFILE
CONCENTRATION (PPMV) (Thousands)
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
TEST TIME (HOURS)


SITE 01 – TEST 10
CARBON MONOXIDE PROFILE
CONCENTRATION (PPMV) (Thousands)
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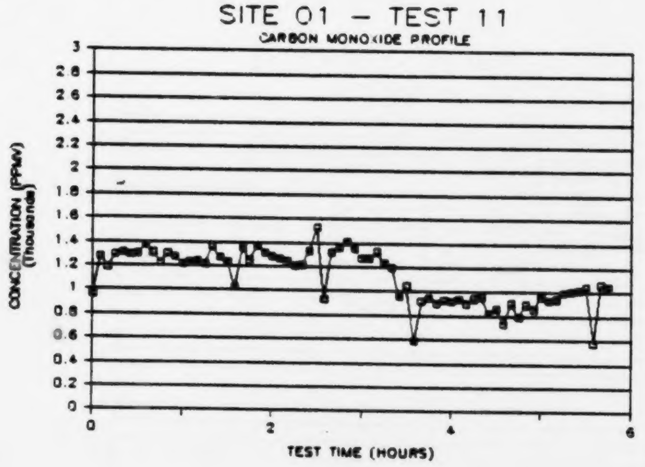
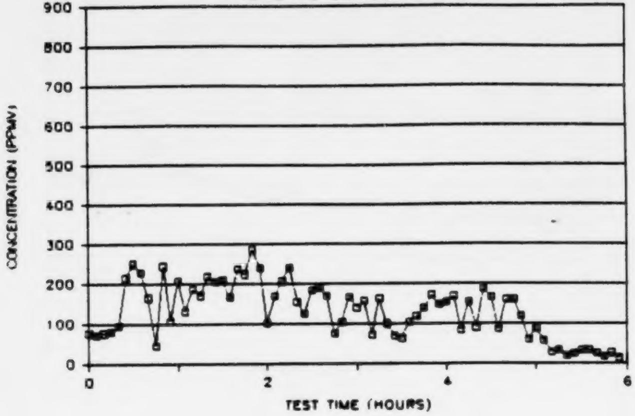
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
TEST TIME (HOURS)


SITE 01 – TEST 11
CARBON MONOXIDE PROFILE
CONCENTRATION (PPMV) (Thousands)
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
TEST TIME (HOURS)

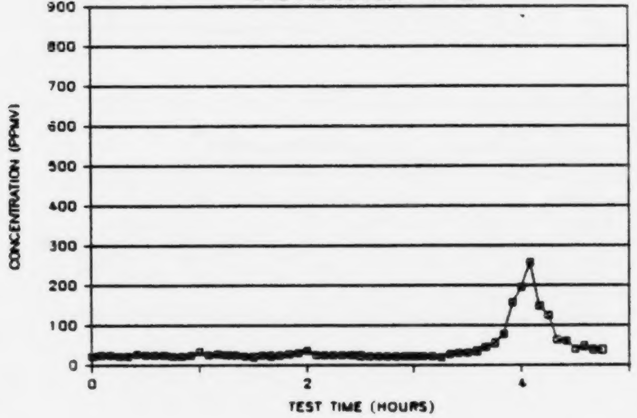
SITE 01 - TEST 9

TOTAL HYDROCARBON PROFILE



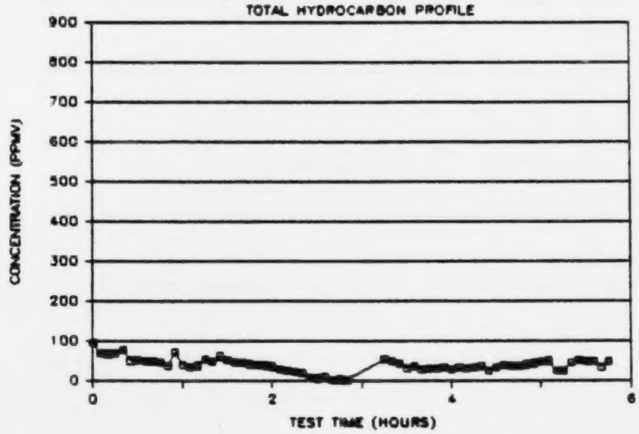
SITE 01 - TEST 10

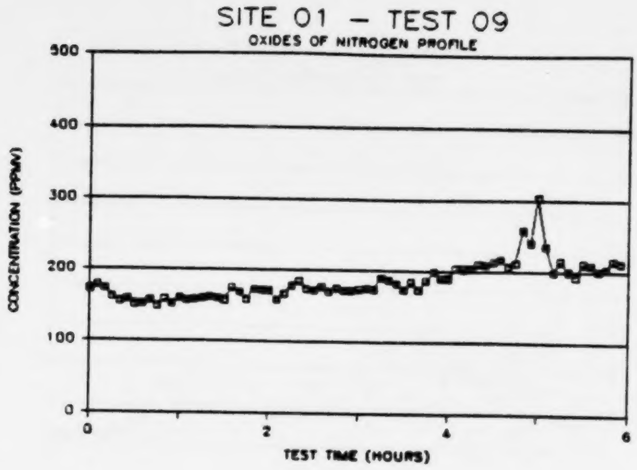
TOTAL HYDROCARBON PROFILE



SITE 01 - TEST 11

TOTAL HYDROCARBON PROFILE




SITE 01 – TEST 09
OXIDES OF NITROGEN PROFILE
CONCENTRATION (PPMV)
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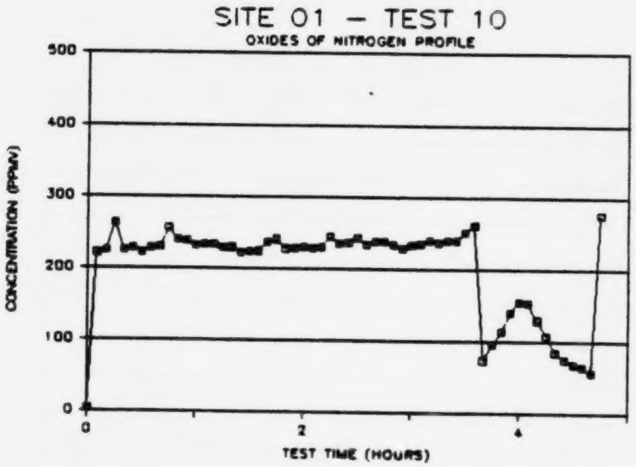
100
200
300
400
500
0
2
4
6
TEST TIME (HOURS)


SITE 01 – TEST 10
OXIDES OF NITROGEN PROFILE
CONCENTRATION (PPMV)
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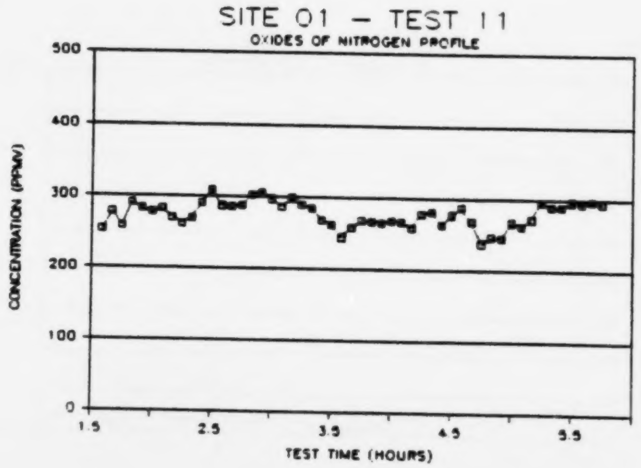
100
200
300
400
500
0
2
4
TEST TIME (HOURS)


SITE 01 – TEST 11
OXIDES OF NITROGEN PROFILE
CONCENTRATION (PPMV)
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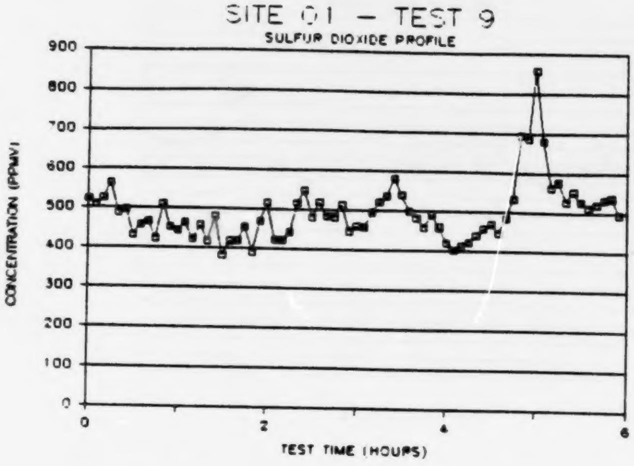
200
300
400
500
1.5
2.5
3.5
4.5
5.5
TEST TIME (HOURS)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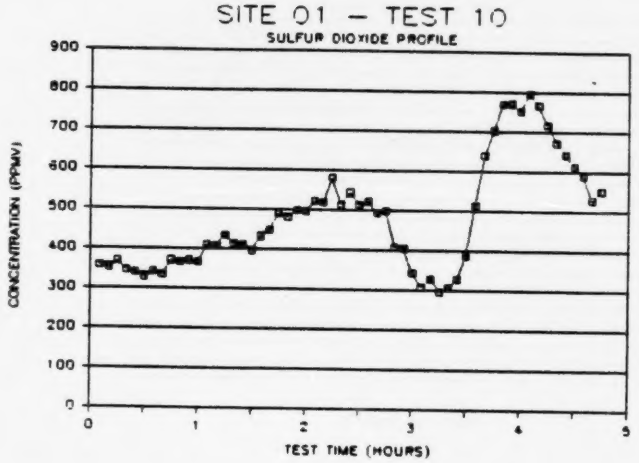
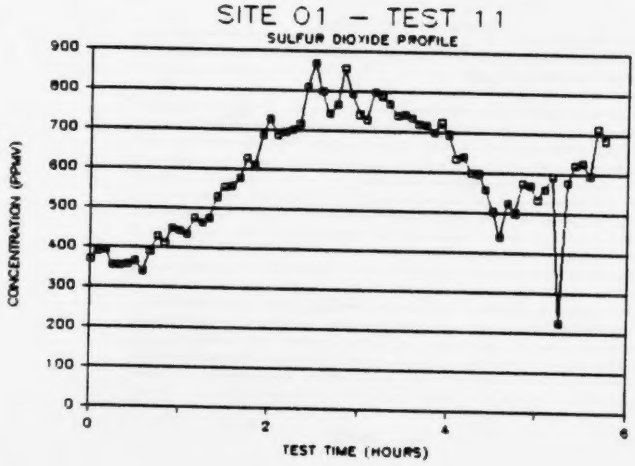
SULFUR DIOXIDE PROFILE


SITE 01 - TEST 10
SULFUR DIOXIDE PROFILE


SITE 01 - TEST 11
SULFUR DIOXIDE PROFILE

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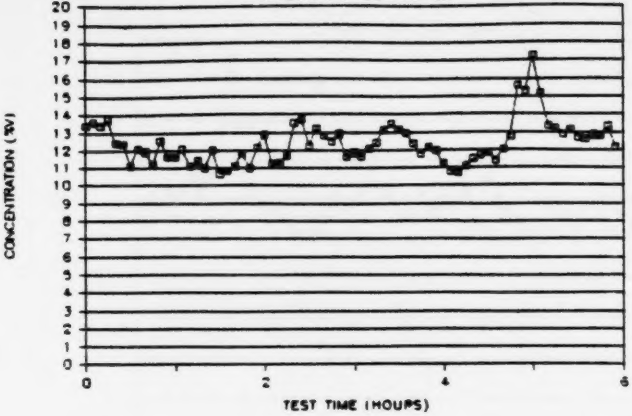
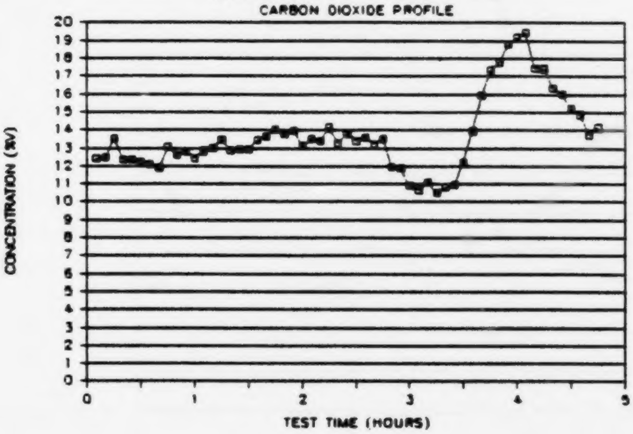
SITE 01 – TEST 9

CARBON DIOXIDE PROFILE



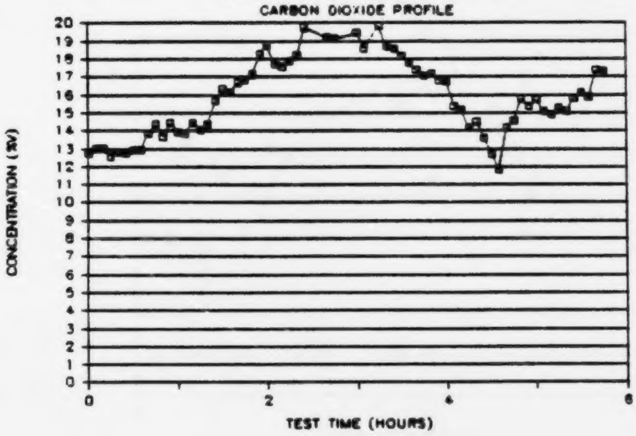
SITE 01 – TEST 10

CARBON DIOXIDE PROFILE



SITE 01 – TEST 11

CARBON DIOXIDE PROFILE



5.3.1 Incinerator Outlet Flue Gas Parameter Data

Table 5-6 summarizes flue gas temperature, moisture, volumetric flow rate, and oxygen concentration data obtained at the incinerator outlet location. These parameters were fairly consistent between test runs. The average flue gas temperature and moisture content measured at this location were 424°C (795°F) and 28.9 vol % respectively. The average dry standard volumetric gas flow rate was 94 dscmm (330 dscfm) and the average actual volumetric gas flow rate was 307 acmm (10,800 scfm). Flue gas oxygen data were obtained from the Radian CEM system and using integrated bag samples (EPA Method 3). The average incinerator outlet flue gas oxygen concentrations measured by these two techniques were 11.9 vol% and 13.8 vol %, respectively (dry basis).

5.3.2 Scrubber Outlet Flue Gas Parameter Data

Table 5-7 summarizes flue gas temperature, moisture, volumetric flow rate, and oxygen concentration data obtained at the scrubber outlet exhaust stack location. These parameters were fairly consistent between test runs. The average flue gas temperature and moisture content measured at this location were 78°C (172°F) and 4.1 vol%, respectively. The average dry standard volumetric gas flow rate was 237 dscmm (8370 dscfm) and the average actual volumetric gas flow rate was 292 acmm (10,300 acfm). The average flue gas oxygen concentration at the scrubber exhaust stack location was 18.1 vol%, as measured by integrated bag samples (EPA Method 3).

5.4 DIOXIN/FURAN EMISSIONS DATA

This section presents the dioxin/furan emissions data developed for Site SSI-A. Incinerator outlet data are discussed in Section 5.4.1, and scrubber outlet data are discussed in Section 5.4.2.

5.4.1 Incinerator Outlet Dioxin/Furan Emissions Data

Quantitative dioxin/furan concentration data were not obtained by Troika for the incinerator outlet MM5 samples. The laboratory report indicated that the sample extracts were yellow in color and that they destroyed the capillary column resolution. Unacceptable surrogate recovery efficiencies were obtained. The laboratory report did indicate that tetra- through octa-CDD and CDF homologues were present in the samples, but the amounts could not be quantified.

TABLE 5-6. INCINERATOR OUTLET FLUE GAS PARAMETERS AT SITE SSI-A

Flue Gas Parameters[a]	Run 09	Run 10	Run 11	Average
Temperature (^{o}C)[b]	397	433	443	424
Moisture (vol %)	26.9	27.6	32.3	28.9
Volumetric Flow Rate[b]				
Actual (acmm)	306	334	282	307
Dry Standard (dscmm)	99.4	101.5	79.5	93.5
Oxygen Content (vol %)				
Radian CEM	12.1	11.9	11.7	11.9
EPA Method 3	12.2	15.3	14.0	13.8

[a] Metric units are reported for all flue gas measurement data.

[b] To convert to alternate units: ^{o}F = 1.8 x ^{o}C + 32
cfm = cmm x 35.3

TABLE 5-7. SCRUBBER OUTLET FLUE GAS PARAMETERS AT SITE SSI-A

Flue Gas Parameters[a]	Run 09	Run 10	Run 11	Average
Temperature (°C)[b]	72	83	80	78
Moisture (vol %)	2.2	1.9	8.2	4.1
Volumetric Flow Rate[b]				
Actual (acmm)	285	298	293	292
Dry Standard (dscmm)	241	244	227	237
Oxygen Content (vol %)				
EPA Method 3	19.7	18.9	16.8	18.1

[a] Metric units are reported for all flue gas measurement data.

[b] To convert to alternate units: °F = 1.8 x °C + 32
cfm = cmm x 35.3

5.4.2 Scrubber Outlet Dioxin/Furan Emissions Data

Emission concentrations and emissions rate data measured at the scrubber outlet are shown in Tables 5-8 and 5-9 for the 2378-TCDD isomer, total PCDD, and total PCDF species. The data include dioxin and furan collected in the entire MM5 train, including the filter, XAD sorbent trap, impingers and sample train clean-up rinses.

Average as-measured emission concentrations of the 2378-TCDD, total PCDD, and total PCDF species were 0.006 ng/dscm 2378-TCDD, 2.84 ng/dscm total PCDD and 6.36 ng/dscm total PCDF. When corrected to 3% O_2 using the EPA Method 3 oxygen concentration data, these values correspond to 0.046 ng/dscm @ 3% O_2, 19.6 ng/dscm @ 3% O_2, and 43.5 ng/dscm @ 3% O_2, respectively. Average emission rates for the three species were 0.089 ug/hr 2378-TCDD, 40.5 ug/hr total PCDD and 90.4 ug/hr total PCDF.

Isomer and homologue-specific emission concentration data are summarized in Tables 5-10 and 5-11 for the three test runs. Run-specific data tables showing homologue emission concentrations in both ng/dscm and parts-per-trillion units and homologue emission rates in ug/hr units are included in Appendix D. As shown in Figure 5-10, the tetra-chlorinated homologues were the largest individual contributors to both total PCDD and total PCDF emissions.

Emission factors for the various dioxin and furan homologues were reasonably consistent between test runs. Emission factors based on the dry sludge feed rate to the incinerator are shown in Table 5-12. Average emission factors for 2378-TCDD, total PCDD, and total PCDF were 0.0002 ug 2378-TCDD emitted per kg dry sludge feed, 0.103 ug total PCDD emitted per kg dry sludge feed, and 0.230 ug total PCDF emitted per kg dry sludge feed.

5.5 DIOXIN/FURAN ANALYSES OF BOTTOM ASH SAMPLES

Table 5-13 shows the run-specific data for the bottom ash samples from Site SSI-A. The concentrations of all dioxin/furan homologues analyzed for were below detectable limits in the three runs. Detection limits ranged from 2 parts per trillion (ppt) for 2378-TCDD to 34 ppt for the hexa-chlorinated dioxin and furan homologues. Scrubber blowdown samples from this test site were not analyzed.

TABLE 5-8. OVERVIEW OF DIOXIN AND FURAN EMISSIONS CONCENTRATION DATA FOR SITE SSI-A (OUTLET)

Run Number	Emissions Concentration, ng/dscm		
	2378-TCDD	Total PCDD	Total PCDF
ng/dscm (as measured)			
Run 09	0.005	3.01	6.56
Run 10	0.009	2.65	5.86
Run 11	0.005	2.88	6.66
Average	0.006	2.84	6.36
ng/dscm @ 3% O_2[a]			
Run 09	0.040	23.9	52.2
Run 10	0.078	22.6	50.0
Run 11	0.019	12.2	28.2
Average	0.046	19.6	43.5

[a] Flue gas concentration data corrected to 3% O_2 using the EPA Method 3 data in Table 5-7.

TABLE 5-9. SUMMARY OF DIOXIN AND FURAN EMISSION RATE DATA FOR SITE SSI-A (SCRUBBER OUTLET LOCATION)

Run Number	Dioxin/Furan Emission Rate, ug/hr 2378-TCDD	Total PCDD	Total PCDF
Run 09	0.074	43.5	94.9
Run 10	0.133	38.7	85.6
Run 11	0.061	39.2	90.6
Average	0.089	40.5	90.4

TABLE 5-10. SUMMARY OF DIOXIN/FURAN EMISSIONS DATA FOR SITE SSI-A
(SCRUBBER OUTLET LOCATION, As-measured Concentrations)

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm)			
	Run 09	Run 10	Run 11	Avg.
DIOXINS				
2378 TCDD	5.08E-03	9.12E-03	4.49E-03	6.23E-03
Other TCDD	1.70E+00	1.62E+00	1.38E+00	1.56E+00
Penta-CDD	2.12E-02	4.19E-02	ND(3.04E-02)	2.10E-02
Hexa-CDD	ND(4.06E-02)	1.24E-01	1.10E-01	7.80E-02
Hepta-CDD	3.79E-01	3.03E-01	4.13E-01	3.65E-01
Octa-CDD	9.02E-01	5.50E-01	9.78E-01	8.10E-01
Total PCDD	3.01E+00	2.65E+00	2.88E+00	2.84E+00
FURANS				
2378 TCDF	NR	NR	NR	NR
Other TCDF	4.91E+00	4.46E+00	4.99E+00	4.79E+00
Penta-CDF	1.59E+00	1.28E+00	1.51E+00	1.46E+00
Hexa-CDF	ND(9.44E-02)	ND(7.30E-02)	7.29E-02	2.43E-02
Hepta-CDF	6.21E-02	7.82E-02	8.19E-02	7.41E-02
Octa-CDF	ND(5.65E-02)	3.65E-02	ND(4.11E-02)	1.22E-02
Total PCDF	6.56E+00	5.86E+00	6.66E+00	6.36E+00

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.
NR = not reported by Troika.
ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
6000 operating hours per year

TABLE 5-11. SUMMARY OF DIOXIN/FURAN EMISSIONS DATA FOR SITE SSI-A
(SCRUBBER OUTLET LOCATION, Concentrations corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm @ 3% oxygen)			
	Run 09	Run 10	Run 11	Avg.
DIOXINS				
2378 TCDD	4.04E-02	7.78E-02	1.90E-02	4.58E-02
Other TCDD	1.35E+01	1.38E+01	5.83E+00	1.11E+01
Penta-CDD	1.68E-01	3.57E-01	ND(1.29E-01)	1.75E-01
Hexa-CDD	ND(3.23E-01)	1.06E+00	4.64E-01	5.09E-01
Hepta-CDD	3.02E+00	2.59E+00	1.75E+00	2.45E+00
Octa-CDD	7.18E+00	4.69E+00	4.14E+00	5.34E+00
Total PCDD	2.39E+01	2.26E+01	1.22E+01	1.96E+01
FURANS				
2378 TCDF	NR	NR	NR	NR
Other TCDF	3.91E+01	3.80E+01	2.11E+01	3.28E+01
Penta-CDF	1.27E+01	1.10E+01	6.41E+00	1.00E+01
Hexa-CDF	ND(7.52E-01)	ND(6.23E-01)	3.09E-01	1.03E-01
Hepta-CDF	4.95E-01	6.67E-01	3.47E-01	5.03E-01
Octa-CDF	ND(4.50E-01)	3.11E-01	ND(1.74E-01)	1.04E-01
Total PCDF	5.22E+01	5.00E+01	2.82E+01	4.35E+01

NOTE: Isomer concentrations shown are corrected to 3% oxygen.
NR = not reported by Troika.
ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
6000 operating hours per year

TABLE 5-12. DIOXIN/FURAN EMISSION FACTORS FOR SITE SSI-A

Dioxin/Furan Isomer	Dioxin/Furan Emission Factors (ug/kg)			
	Run 09	Run 10	Run 11	Avg.
DIOXINS				
2378 TCDD	2.09E-04	3.09E-04	1.49E-04	2.22E-04
Other TCDD	7.00E-02	5.48E-02	4.55E-02	5.68E-02
Penta-CDD	8.71E-04	1.42E-03	ND(1.01E-03)	7.64E-04
Hexa-CDD	ND(1.67E-03)	4.22E-03	3.63E-03	2.62E-03
Hepta-CDD	1.56E-02	1.03E-02	1.37E-02	1.32E-02
Octa-CDD	3.71E-02	1.86E-02	3.23E-02	2.94E-02
Total PCDD	1.24E-01	8.97E-02	9.53E-02	1.03E-01
FURANS				
2378 TCDF	NR	NR	NR	NR
Other TCDF	2.02E-01	1.51E-01	1.65E-01	1.73E-01
Penta-CDF	6.55E-02	4.35E-02	5.01E-02	5.30E-02
Hexa-CDF	ND(3.89E-03)	ND(2.47E-03)	2.41E-03	8.03E-04
Hepta-CDF	2.56E-03	2.65E-03	2.71E-03	2.64E-03
Octa-CDF	ND(2.33E-03)	1.24E-03	ND(1.36E-03)	4.12E-04
Total PCDF	2.70E-01	1.99E-01	2.20E-01	2.30E-01

NR = not reported by Troika.
ND = not detected (detection limit in parentheses).
ug = 1.0E-06g
6000 operating hours per year

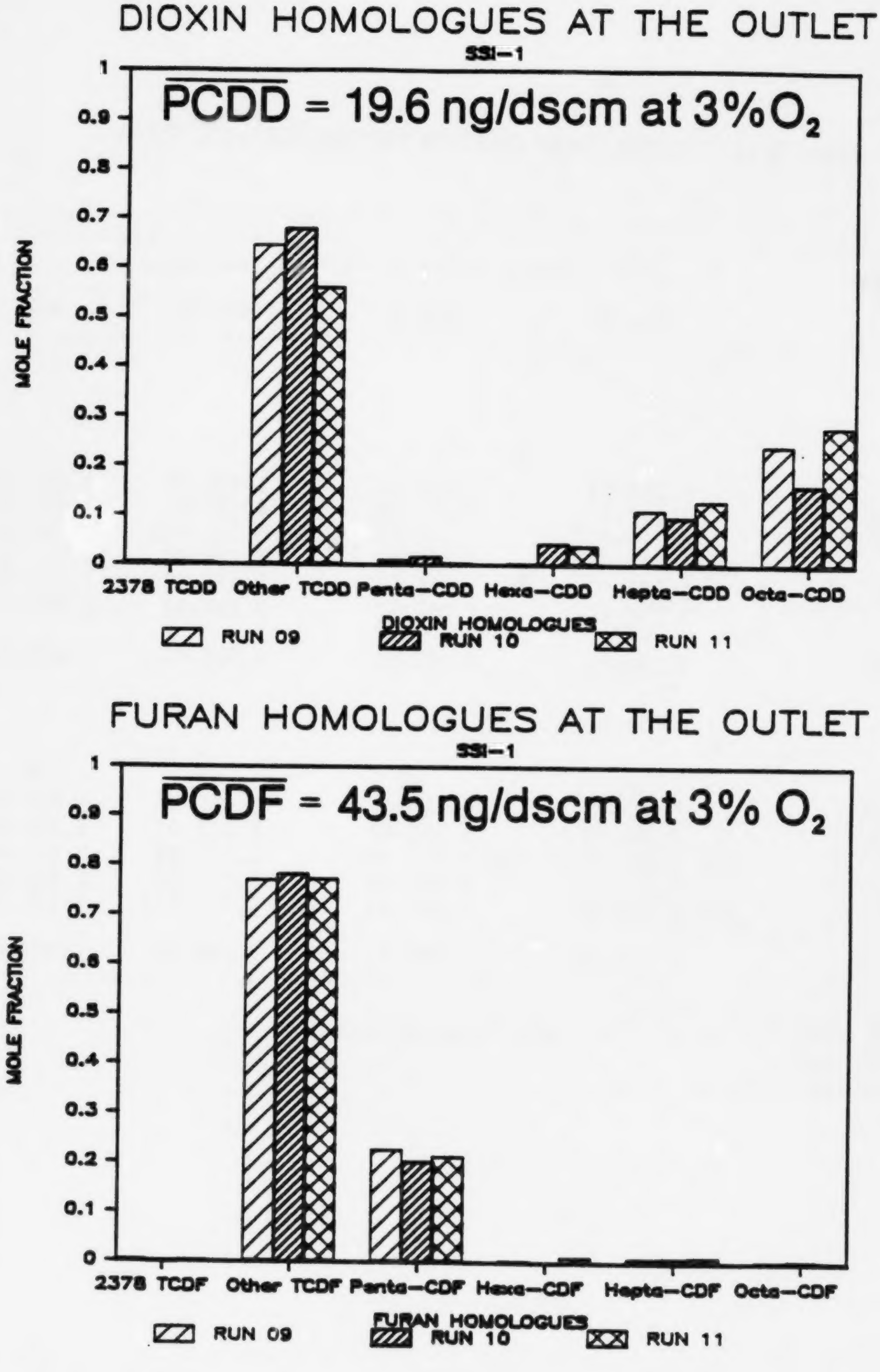


Figure 5-10. Distribution of dioxin and furan homologues in scrubber outlet emissions.

TABLE 5-13. DIOXIN/FURAN CONTENTS OF INDIVIDUAL BOTTOM ASH SAMPLES FROM SITE SSI-A

Isomer/ Homologue	Dioxin/Furan Homologue Contents (ppt)		
	Run 09	Run 10	Run 11
Dioxins			
2378-TCDD	ND	ND	ND
Other TCDD	ND	ND	ND
Penta CDD	ND	ND	ND
Hexa CDD	ND	ND	ND
Hepta CDD	ND	ND	ND
Octa CDD	ND	ND	ND
Total PCDD	ND	ND	ND
Furans			
2378-TCDF	NR	NR	NR
Other TCDF	ND	ND	ND
Penta CDF	ND	ND	ND
Hexa CDF	ND	ND	ND
Hepta CDF	ND	ND	ND
Octa CDF	ND	ND	ND
Total PCDF	ND	ND	ND

ND = not detected. Analytical detection limits ranged from 2 parts per trillion for 2378-TCDD to 34 parts per trillion for the hexa-CDD/CDF homologues.

NR = not reported by Troika. Speciation of the 2378-TCDF isomer was not performed for this test site.

5.6 SLUDGE FEED AND FUEL OIL PRECURSOR ANALYSES

As discussed in Section 6, sludge and fuel oil samples were taken at Site SSI-A. The average solids content of the sludge was 21.1 weight percent and the average volatiles content of the solids was 69.3 weight percent. These samples were analyzed for chlorinated benzenes, chlorinated biphenyls, and chlorinated phenols. In addition, both the sludge and the fuel oil samples were analyzed for total chlorine.

Table 5-14 summarizes the results of the compound-specific precursor analysis of the sludge feed. Dichlorobenzene was the only precursor detected, and 0.01 ug/g (ppm) was found. None of the chlorinated biphenyls or phenols were detected. The total chlorine concentration of the sludge was 606 ug/g (ppm), and the total chlorine concentration of the fuel oil sample was 35 ug/g (ppm).

5.7 AMBIENT XAD TRAIN DATA

Dioxin/furan analyses were not performed on the ambient air samples taken at Site SSI-A.

5.8 SOIL SAMPLING DATA

The soil sample was archived pending evaluation of analytical data.

TABLE 5-14. SUMMARY OF DIOXIN PRECURSOR DATA FOR SITE SSI-A FEED SAMPLES

Precursor Categories	Precursor Concentrations, ug/g (ppm) Sludge Feed Samples Run 09	Run 10	Run 11	Average
Total Chlorinated Benzenes	0.01[a]	ND	ND	0.003
Total Chlorinated Biphenyls	ND	ND	ND	ND
Total Chlorinated Phenols	ND	ND	ND	ND
Total Chlorine	620	606	591	606

[a] Dichlorobenzene was the only chlorinated precursor detected.

6.0 SOURCE SAMPLING LOCATIONS AND PROCEDURES

This section describes the field sampling and analytical measurements that were performed for the test program. Specific sampling locations, sampling methods, and sampling procedures are described.

6.1 GASEOUS SAMPLES

Four types of gaseous samples were taken during the test program: Modified Method 5 (MM5), Continuous Emissions Monitoring (CEM), integrated bag sampling, and combustion air sampling. The sampling locations and methods are further discussed in this section.

6.1.1 Gaseous Sampling Locations

6.1.1.1 Incinerator Outlet Sampling Location. The incinerator outlet sampling location is shown as point B on Figure 4-1. This location was used for dioxin/furan sampling using MM5, continuous monitoring of CO, CO_2, NO_x, SO_2, THC and O_2, and integrated bag sampling for molecular weight determination. The continuous monitoring was performed at the incinerator outlet because it is upstream of the control device and thus the data are more representative of combustion conditions in the incinerator. There was little chance for air inleakage prior to the sampling location. The representativeness of the sampling location at the incinerator outlet for the Modified Method 5 organic sampling (MM5) is discussed below.

Dimensions of the incinerator outlet sampling location relative to the nearest flow disturbances are shown in Figure 6-1. The six sample ports were located in a vertical rectangular duct with a 6" thick layer of refractory on all sides. The effective inside dimensions of the duct were approximately 33" x 36". The sampling ports were located 48" above the top of the furnace (~1.5 E_D downstream of the furnace) and 16" (~.5 E_D) below a 90 degree bend in the ductwork that leads to the cyclones.[a] Three of the sample ports were located on the east side of the duct, and the other three ports were located on the south side of the duct. The horizontal spacing of the ports was designed to yield equal areas of the stack for gaseous and particulate sampling. The MM5

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[a] The notation E_D denotes equivalent duct diameters as defined in EPA Method 1.

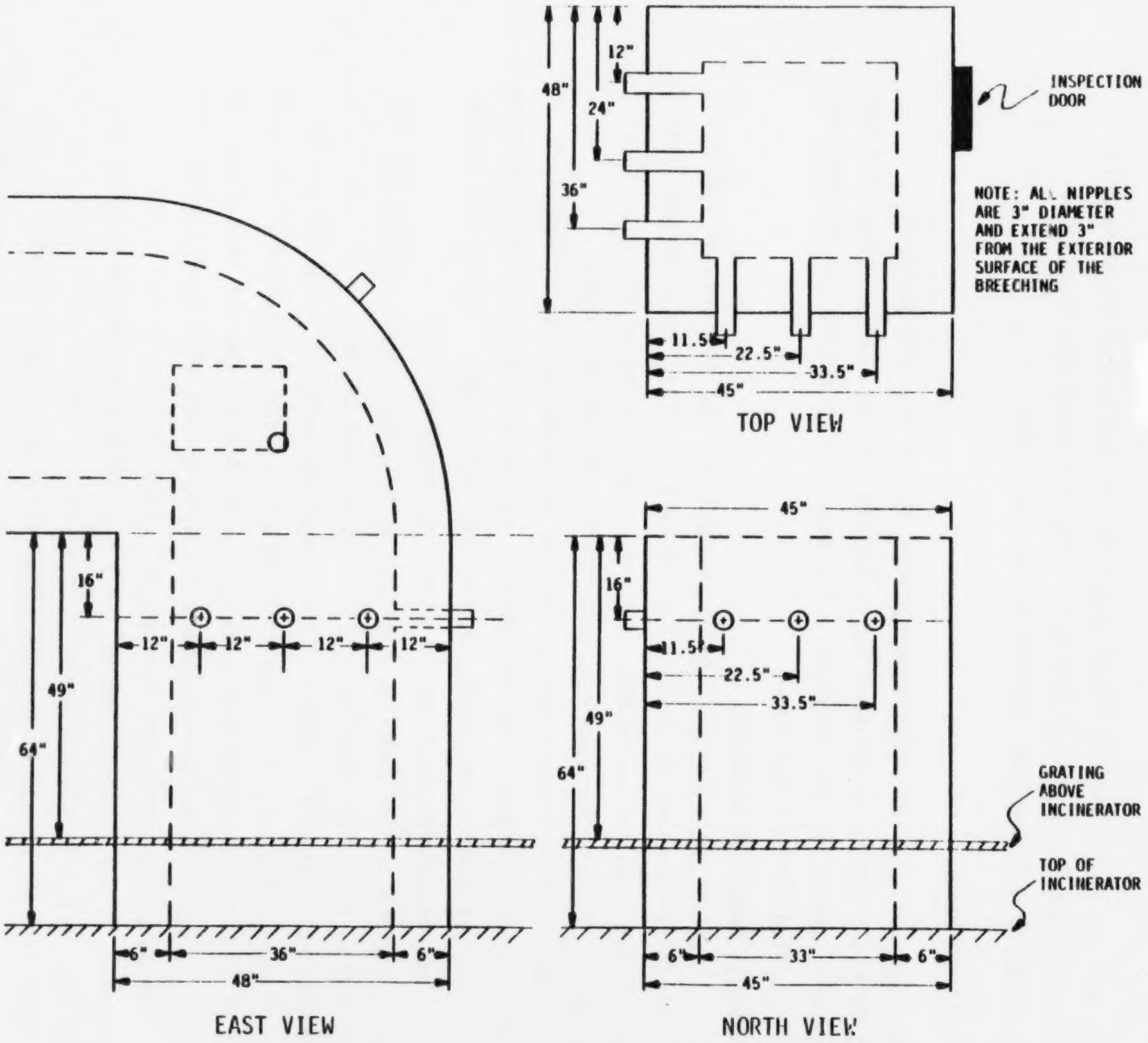

12"
24"
36"
48"
INSPECTION DOOR
NOTE: ALL NIPPLES ARE 3" DIAMETER AND EXTEND 3" FROM THE EXTERIOR SURFACE OF THE BREECHING
11.5"
22.5"
33.5"
45"
TOP VIEW
16"
49"
64"
12"
12"
12"
12"
6"
36"
6"
48"
EAST VIEW
45"
16"
11.5"
22.5"
33.5"
49"
64"
GRATING ABOVE INCINERATOR
TOP OF INCINERATOR
6"
33"
6"
45"
NORTH VIEW

Figure 6-1. Incinerator Outlet Sampling Location.

sample traverse at the incinerator outlet consisted of three points for each of the three sampling ports on the east side of the duct for a total of nine traverse points.

6.1.1.2 Scrubber Outlet Sampling Location. The scrubber outlet sampling location is shown as point A on Figure 4-1. This location was used for dioxin/furan sampling using MM5 and for integrated bag sampling. The two sample ports used for the MM5 traverse were located 90^o apart on a round stack with an inside diameter of 48 inches. Dimensions of the sampling location relative to the nearest flow disturbances are shown in Figure 6-2. The ports were located 49 inches above the roof level and 254 inches downstream of the induced draft fan. The ports were 109 inches ($>2\ E_D$) from the nearest potential upstream flow disturbance (shaft cooling air inlet) and 61 inches ($>1\ E_D$) from the nearest downstream flow disturbance (stack exhaust to atmosphere).

6.1.1.3 Combustion Air Sampling Location. Combustion air sampling was performed adjacent to the incinerator combustion air intake screen. The selected location was at ground level on the north side of the incinerator building. The ambient XAD sample train intake was located approximately 1 foot below the louvered screens of the incinerator combustion air intake. The location was adequate for screening potential dioxin/furan or precursor inputs into the combustion system from the ambient air.

6.1.2 Gaseous Sampling Procedures

Gaseous sampling procedures used during this program are discussed in detail in the Tier 4 Quality Assurance Project Plan (QAPP). A brief description of each method and any necessary modifications of the procedures as outlined in the QAPP are provided in the following sections.

6.1.2.1 Modified Method 5 (MM5). Gas sampling for dioxins and furans was conducted according to the August 1984 draft of the ASME chlorinated organic compound sampling protocol. This sampling method is a modified version of EPA Method 5 that includes a solid sorbent module for trapping vapor phase organics. The MM5 sampling train was used to collect samples at the incinerator outlet location and at the scrubber outlet exhaust stack. Following sample recovery, the various parts of the sample (filter, solvent rinses, sorbent trap, etc.) were sent to the EPA's Troika laboratories to

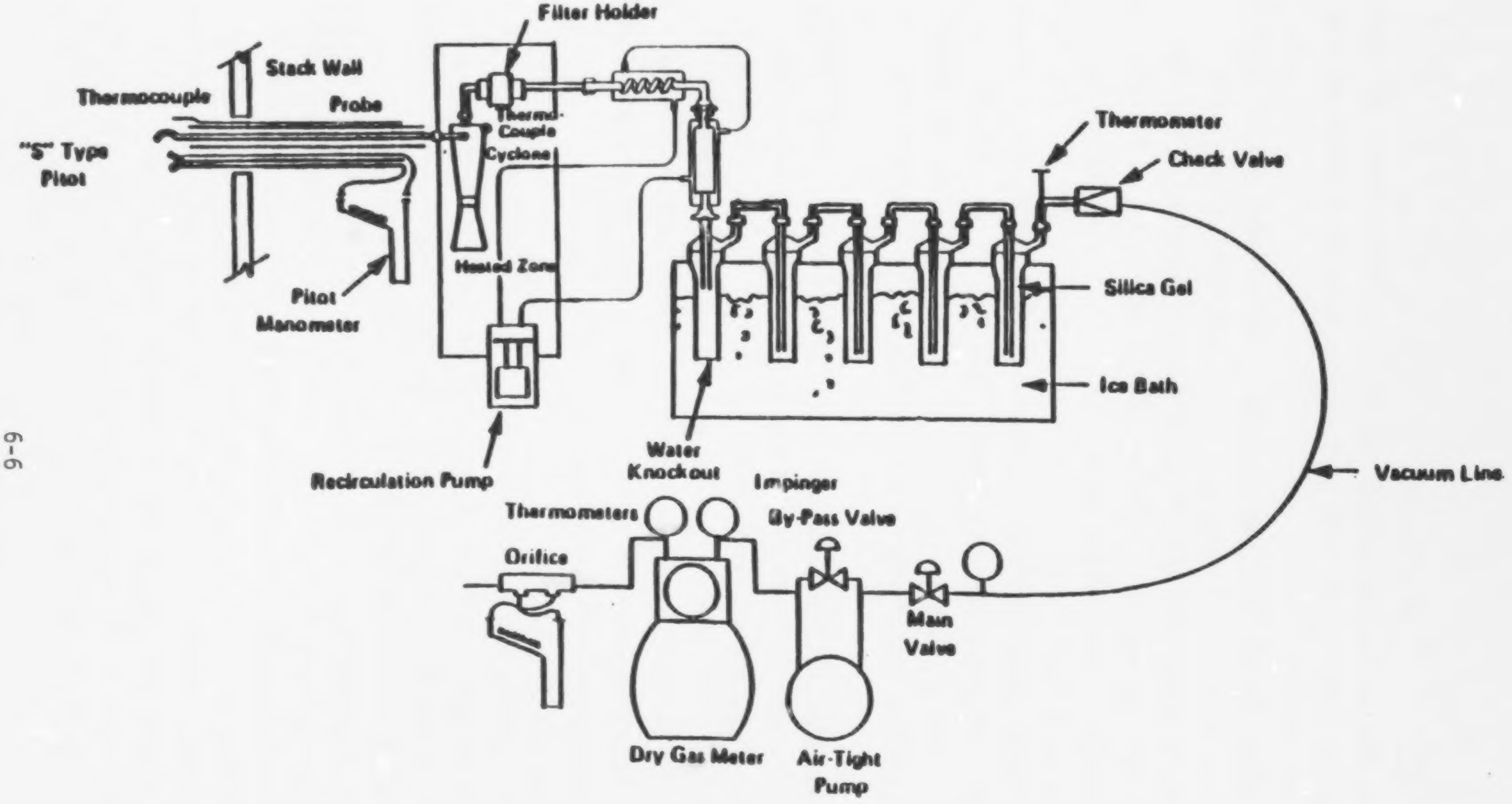
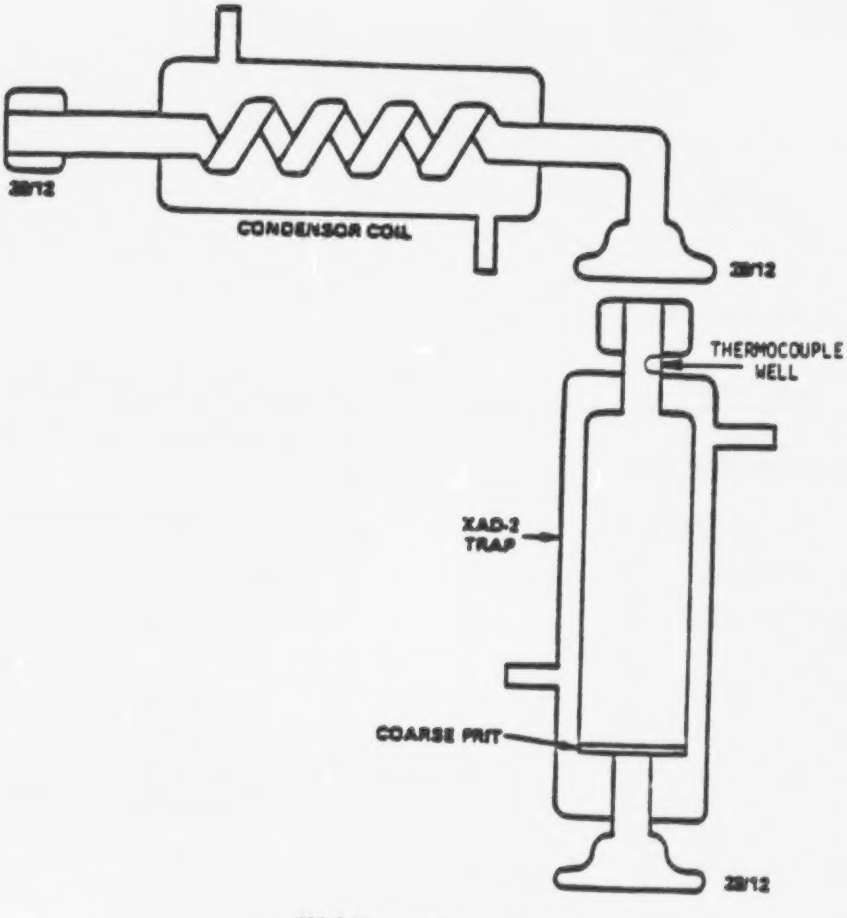

Filter Holder
Stack Wall
Thermocouple
Probe
"S" Type Pitot
Thermo-Couple
Cyclone
Heated Zone
Pitot Manometer
Recirculation Pump
Thermometer
Check Valve
Silica Gel
Ice Bath
Water Knockout
Impinger
Vacuum Line
Thermometers
By-Pass Valve
Orifice
Main Valve
Dry Gas Meter
Air-Tight Pump

Figure 6-3. Modified Method 5 Train


28/12
CONDENSOR COIL
28/12
THERMOCOUPLE WELL
XAD-2 TRAP
COARSE FRIT
28/12

XAD-2 Trap and Condenser Coil.

Figure 6-4. Adsorbent Sampling System

AMBIENT XAD TRAIN

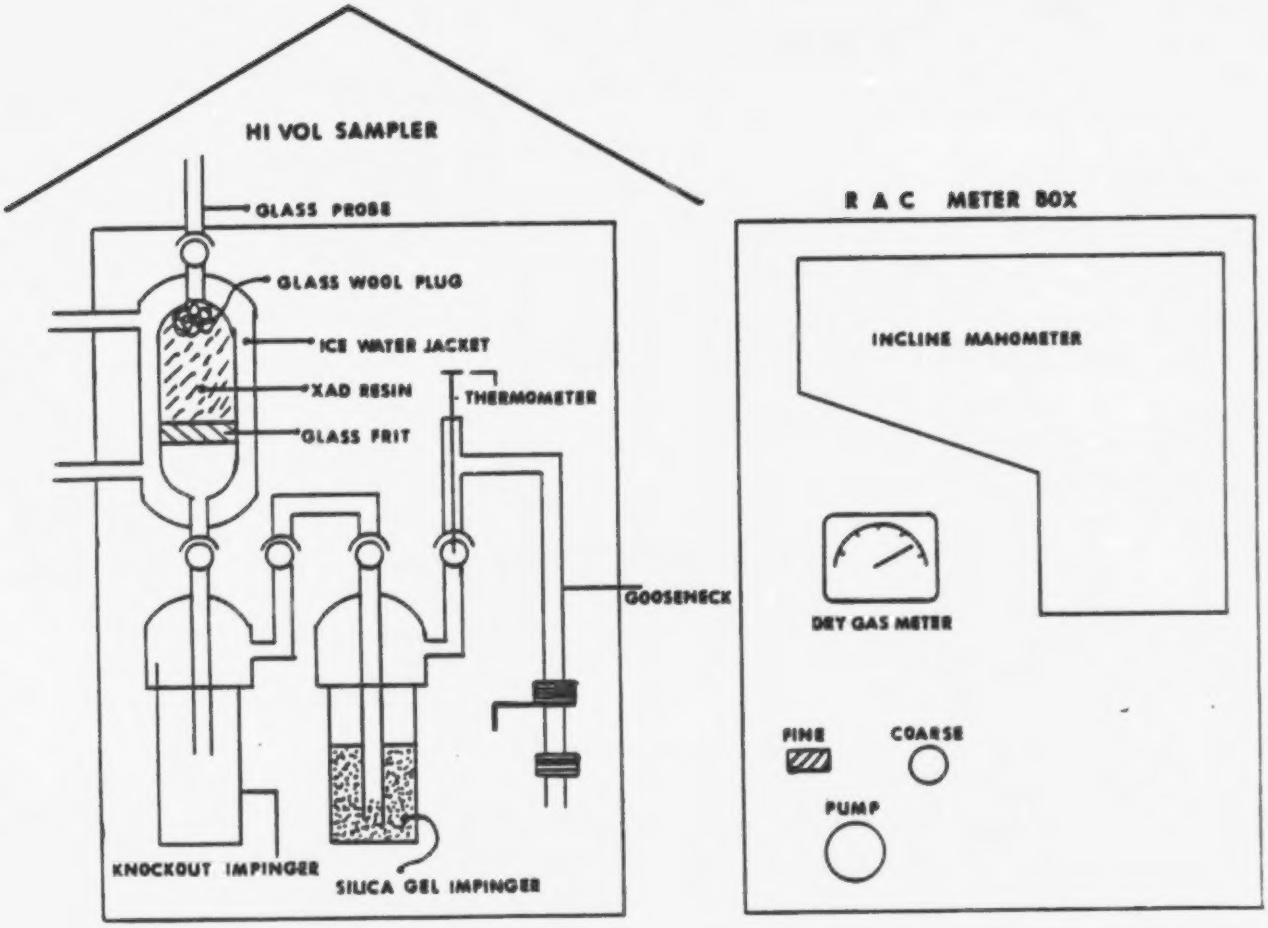

HI VOL SAMPLER
GLASS PROBE
GLASS WOOL PLUG
ICE WATER JACKET
XAD RESIN
THERMOMETER
GLASS FRIT
GOOSENECK
KNOCKOUT IMPINGER
SILICA GEL IMPINGER
RAC METER BOX
INCLINE MANOMETER
DRY GAS METER
FINE
COARSE
PUMP

Figure 6-5. Diagram of Ambient XAD Train.

similar to that of the MM5 train. The resin tubes were capped with precleaned foil, and the XAD sorbent traps from the sample trains were sent to the Troika and Radian, Research Triangle Park (RTP) laboratories for potential dioxin/furan and precursor analysis, respectively.

6.1.2.3 Volumetric Gas Flow Rate Determination. The volumetric gas flow rate was determined using procedures described in EPA Method 2. Based on this method, the volumetric gas flow rate is determined by measuring the cross-sectional area of the duct and the average flue gas velocity. The average flue gas velocity is calculated from the average gas velocity pressure (Δ P) across an S-type pitot tube, the average flue gas temperature, wet molecular weight, and the absolute static pressure.

6.1.2.4 Flue Gas Moisture Determination. The moisture content of the flue gas was determined using the EPA Method 4. Based on this method, a known volume of particulate-free gas is pulled through a chilled impinger train. The quantity of condensed water is determined gravimetrically and then related to the volume of gas sampled to determine the moisture content.

6.1.2.5 Flue Gas Molecular Weight Determination. During testing, the integrated sampling technique described in EPA Method 3 was used to obtain integrated flue gas samples for fixed gas (O_2, CO_2, CO, N_2) analysis. A small diaphragm pump and a stainless steel probe were used to extract a single-point flue gas sample which was collected in a Tedlar bag. Moisture was removed from the gas sample by a water-cooled condenser so that the fixed gas analysis was on a dry basis.

The composition of the gas sample was determined using a Shimadzu Model 3BT analyzer. This instrument employs a gas chromatograph and a thermal conductivity detector. Calibration of the Shimadzu analyzer was conducted according to the procedures outlined in the QAPP, which involved analysis of one or more standards of appropriate composition immediately before and after sample analysis.

6.1.2.6 Continuous Monitoring. Continuous monitoring was performed at the incinerator outlet (scrubber inlet) sampling location for O_2, CO_2, CO, NO_x, SO_2, and THC. The continuous monitoring was performed throughout the 4 to 5-hour period that MM5 sampling was being conducted each test day. The primary objectives of the continuous monitoring effort were to observe fluctuations in flue gas parameters, and to provide an indication of incinerator combustion conditions. Sample acquisition was accomplished using an in-stack filter probe and 24 m (80ft) of heat-traced Teflon sample line maintained at a temperature of 150°C (300°F). The stack gas sample was drawn through the filter and heated sample line using pumps located in the mobile laboratory. Sample gas to be analyzed for CO, CO_2, O_2, NO_x, and SO_2 was then pumped through a sample gas conditioner, consisting of an ice bath and knockout trap, to remove moisture. This provided a dry gas stream for analysis. A separate unconditioned gas stream was supplied to the THC analyzer for analysis on a wet basis.

An Anarad Model 412 nondispersive infrared (NDIR) analyzer was used to measure CO and CO_2; a Beckman Model 755 paramagnetic analyzer was used to measure O_2; a Teco Model 10 chemiluminescent analyzer was used to measure NO_x; a Teco Model 40 pulsed fluorescence analyzer was used to measure SO_2; and a Beckman Model 402 flame ionization analyzer was used to measure THC. Calibration of the continous monitors was performed according to the procedures in the QAPP. These procedures included a three point (two upscale plus zero) linearity check on the first test day, single point and zero point calibration checks daily, and single point drift checks at the end of each test day.

6.2 LIQUID SAMPLES

Two types of liquid samples were obtained: scrubber blowdown and fuel oil. Sampling locations and procedures are discussed below.

6.2.1 Scrubber Blowdown Sampling

The scrubber water system at the host site is a once-through system. Treatment plant effluent is fed to the scrubber, and the entire blowdown stream is sent back to the treatment plant with no recycle to the scrubber.

The sampling location for the scrubber blowdown stream was directly below the scrubber system, prior to mixing with any other wastewater streams. A sample valve fitted with a rubber hose was used for the sampling. Scrubber blowdown water was allowed to run through the rubber hose for several minutes prior to taking the sample.

A 1-liter composite scrubber blowdown sample was prepared for each test run. The composite sample was prepared from hourly 500 ml samples taken throughout the run. The hourly samples were composited in a large clear glass jar. Because of the low solids loading in the scrubber blowdown, settling of solids in the samples was not a problem. The 1-liter hourly sample composite for each run was sent to Troika for potential dioxin/furan analyses.

6.2.2 Fuel Oil Sampling

No. 2 fuel oil is fired as auxiliary fuel in the incinerator. The sampling location was in the fuel oil line leading to the burners. A sample valve fitted with a short metal spout was used for sampling. Approximately one liter of fuel oil was allowed to bleed through the sample spout prior to sampling.

Two 1-liter composite fuel oil samples were prepared for each test run. The composite samples were prepared from hourly 150 ml samples taken throughout the run. The hourly samples were composited in 1-liter amber glass jars. One of the composites was sent to Troika for potential dioxin/furan analysis, and the other composite was sent to Radian/RTP for potential dioxin/furan precursor analysis. An aliquot of the Radian/RTP sample was later sent to Research Triangle Institute (RTI) for total chlorine analyses.

6.3 SOLID SAMPLES

Three types of solid samples were obtained: sludge feed, bottom ash, and soils. Sampling locations and procedures are discussed below.

6.3.1 Sludge Feed Sampling

Sludge feed samples were obtained directly from the incinerator belt feeder. Plant personnel routinely sample the sludge on an hourly basis and analyze the 24-hour sample composites for solids and volatiles content. Plant personnel were provided with a pre-cleaned metal trowel and asked to take additional samples for the Tier 4 program at the same time they took samples for the solids/volatiles analyses. Each hourly Tier 4 sample consisted of approximately 500g (1.1 lb of sludge). The hourly samples were composited in a large clear glass jar. At the end of each run, the sludge sample composite was mixed using a pre-cleaned mixer blade attached to an electric drill.

Two 1-liter composite sludge samples were developed for each test run. One of the composites was sent to Troika for potential dioxin/furan analysis, and the other composite was sent to Radian/RTP for dioxin/furan precursor analysis.

6.3.2 Incinerator Bottom Ash Sampling

Incinerator bottom ash was sampled at the point of discharge from the screw conveyor that transports the ash from the bottom hearth of the incinerator. The ash was sampled as it was discharged into a large hopper. A pre-cleaned metal bucket attached to a long handle was used for the sampling. The bucket was held directly below the spout to capture the falling bottom ash.

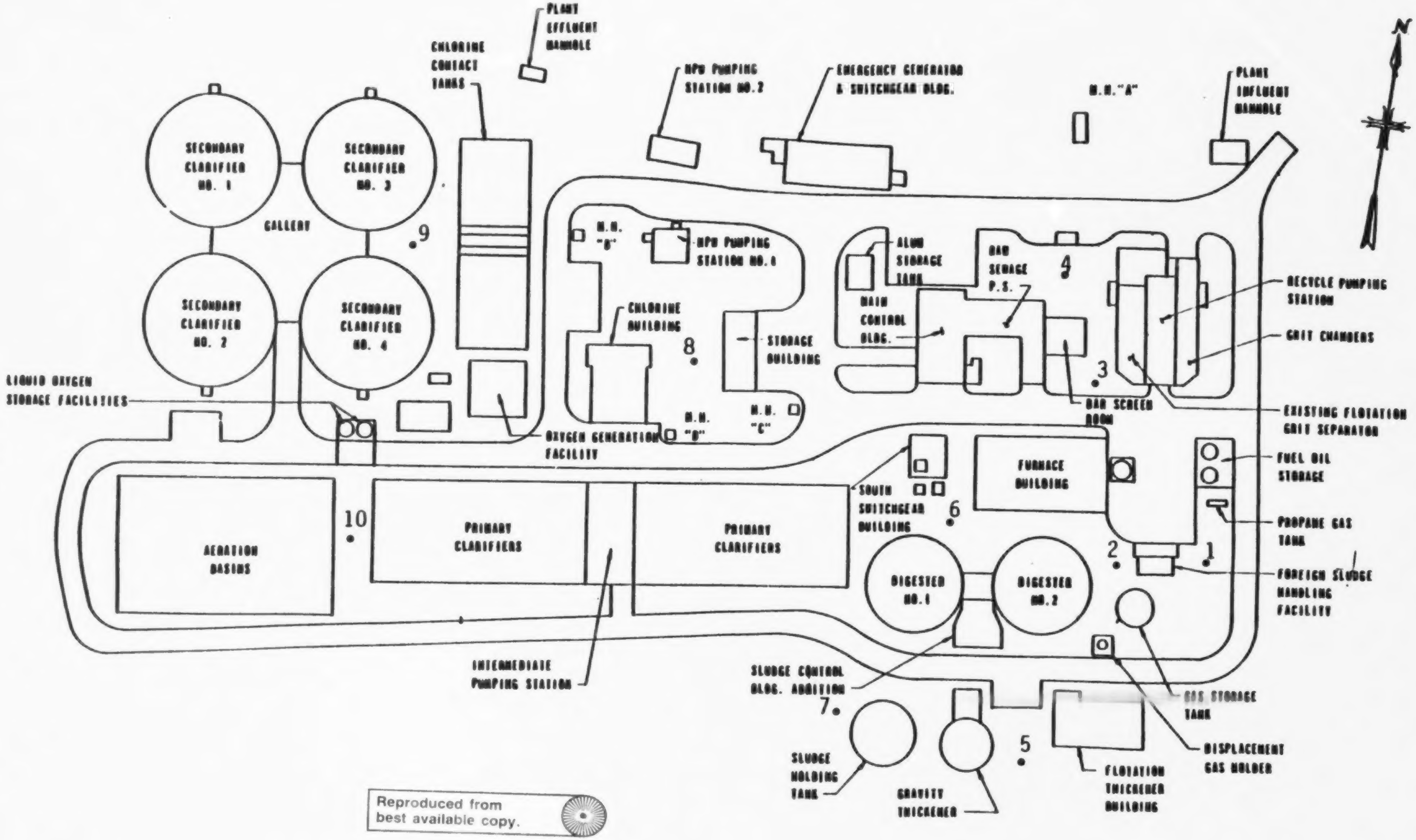
A 1-liter composite bottom ash sample was developed for each test run. The composite samples were prepared from two 250 ml samples taken at the beginning and end of each run. The composite was sent to Troika for dioxin/furan analysis. The analytical results for these samples were presented in Section 5.5.

6.3.3. Soil Sampling

Soil samples were taken from 10 locations at the host site using a pre-cleaned bulb planter. One composite sample was prepared from the 10 individual samples. The individual samples were composited in a pre-cleaned metal bucket.

The sampling locations shown in Figure 6-6 were selected such that all areas of the plant were represented. Most of the samples were taken on the east side of the plant near the furnace building and the associated ash handling area.

The composite soil sample was transferred to Tier 7 of the National Dioxin Study for potential dioxin/furan analysis.


N
PLANT EFFLUENT MANHOLE
CHLORINE CONTACT TANKS
HPO PUMPING STATION NO. 2
EMERGENCY GENERATOR & SWITCHGEAR BLDG.
M.H. "A"
PLANT INFLUENT MANHOLE
SECONDARY CLARIFIER NO. 1
SECONDARY CLARIFIER NO. 3
GALLERY
9
SECONDARY CLARIFIER NO. 2
SECONDARY CLARIFIER NO. 4
M.H. "B"
HPO PUMPING STATION NO. 1
CHLORINE BUILDING
8
STORAGE BUILDING
ALUM STORAGE TANK
RAW SEWAGE P.S.
4
MAIN CONTROL BLDG.
RECYCLE PUMPING STATION
GRIT CHAMBERS
3
BAR SCREEN ROOM
EXISTING FLOTATION GRIT SEPARATOR
LIQUID OXYGEN STORAGE FACILITIES
OXYGEN GENERATION FACILITY
M.H. "D"
M.H. "C"
FURNACE BUILDING
FUEL OIL STORAGE
SOUTH SWITCHGEAR BUILDING
6
PROPANE GAS TANK
2
1
FOREIGN SLUDGE HANDLING FACILITY
10
AERATION BASINS
PRIMARY CLARIFIERS
PRIMARY CLARIFIERS
DIGESTER NO. 1
DIGESTER NO. 2
INTERMEDIATE PUMPING STATION
SLUDGE CONTROL BLDG. ADDITION
GAS STORAGE TANK
DISPLACEMENT GAS HOLDER
7
5
SLUDGE HOLDING TANK
GRAVITY THICKENER
FLOTATION THICKENER BUILDING

Reproduced from best available copy.

Figure 6-6. Sampling Locations (Sampling Locations Indicated by Number).

7.0 ANALYTICAL PROCEDURES

Laboratory procedures used to quantify dioxins/furans and dioxin/furan precursors in the Tier 4 samples are described in this section. MM5 train samples were analyzed by EPA's Troika laboratories for dioxin/furan content. Procedures used for these analyses are described in detail in the Analytical Procedures and QA Plan for the Analysis of Tetra through Octa-CDD's and CDF's in Samples from Tier 4 Combustion and Incineration Processes (addendum to EPA/600/3-85-019, April 1985). These procedures are summarized in Section 7.1.

Sludge feed samples from Site SSI-A were analyzed by Radian to determine concentrations of chlorinated phenols (CP), chlorobenzenes (CB), and polychlorinated biphenyls (PCBs). Sludge feed and fuel oil samples were analyzed by Research Triangle Institute (RTI) for total chlorine. Procedures used for these analyses are detailed in Section 7.2.

7.1 DIOXINS/FURANS

The analytical procedures summarized in this section were used by Troika for dioxin/furan analysis of MM5 train samples from Site SSI-A. Samples consisting of organic solvents, aqueous solutions, and solids were prepared for analysis using slightly different procedures. The organic solvent samples included rinses from the MM5 probe, nozzle, filter housing and condenser coil. Aqueous samples consisted of impinger catch solutions, and solid samples included filters and XAD resin. Isotopically-labeled surrogate compounds were added to all samples prior to extraction to allow determination of method efficiency and for quantification purposes.

Organic liquid samples (e.g., acetone and hexane-based MM5 train rinses) were concentrated using a nitrogen blowdown apparatus. The residue, which contained particulate matter from the MM5 train probe and nozzle, was combined with the filter and handled as a solid sample. Solid samples were extracted with benzene in a Soxhlet apparatus for a period of at least 16 hours. The extract was concentrated by nitrogen blowdown and subjected to chromatographic cleanup procedures.

Aqueous solutions (e.g., MM5 train impinger samples) were extracted with hexane by vigorous shaking for a three hour period. This extraction procedure was repeated three times, and the organic fractions were combined and concentrated for chromatographic cleanup.

The cleanup procedure involved using liquid chromatographic columns to separate the compounds of interest from other compounds present in the samples. Four different types of columns were used: a combination acid and base modified silica gel column, a basic alumina column, a PX-21 carbon/celite 545 column and a silica/diol micro column. These were used in successive steps, with the last two being used only if necessary.

The cleaned samples were analyzed using high resolution gas chromatography/high resolution mass spectrometry (GC/MS). GC/MS conditions for the analyses were as follows:

Gas Chromatograph - Injector configured for capillary column, splitless injection, injector temperature 280°C, helium carrier gas at 1.2 ml/min, initial column temperature 100°C, final column temperature 240°C, interface temperature 270°C.

Mass Spectrometer - Varian/MAT Model 311A, electron energy 70ev, filament emission 1MA, mass resolution 8000 to 10,000, ion source temperature 270°C.

7.2 DIOXIN/FURAN PRECURSORS

Feed samples for Site SSI-A were analyzed by Radian/RTP for chlorophenols (CP), chlorobenzenes (CB) and polychlorinated biphenyls (PCBs) by GC/MS; and total chlorine by Parr Bomb combustion followed by ion chromatography. Analytical procedures are discussed in the following sections.

7.2.1 GC/MS Analyses

The analytical procedures used for determining CP, CB, and PCB concentrations in feed samples are modified versions of procedures typically used for the analysis of MM5 train components. These procedures involve initial extraction of the sample with an appropriate solvent, preliminary separation of the compounds of interest by solvent partitioning and liquid chromatography, and analysis of the processed fractions. Solutions containing

CB and PCB are injected directly into the GC/MS, and solutions containing CP are derivatized prior to injection. Details on the procedures used for Site SSI-A samples are provided in the sections below.

7.2.1.1 Sample Preparation

A flow chart for the sample preparation procedure used for Site SSI-A feed samples is shown in Figure 7-1. The first step in the procedure involved adding labeled surrogate compounds to provide a measure of extraction method efficiency. The next step involved adding a mixture of 50:50 $MeCl_2$/Hexanes to the sample and sonicating the sample for 30 minutes. The sonicated sample was filtered and the filtrate was extracted three times in a separatory funnel with 50 ml 0.5 N NaOH and the aqueous and organic fractions were saved for derivatization and/or further cleanup. The aqueous fraction (or acids portion) was acidified to pH 2.0 with 1:1 H_2SO_4 and then extracted three times with 50 ml $MeCl_2$. The $MeCl_2$ from this extraction was dried with anhydrous Na_2SO_4, exchanged to benzene, and concentrated using a nitrogen blowdown apparatus. Acetylation of any CP present in the sample involved the following steps:

1. 2.0 mL isooctane, 2.0 mL acetonitrile, 50 uL pyridine, and 20 uL acetic anhydride were added to the extract. The test tube containing the extract was placed in a 60°C water bath for 15 minutes and was shaken 30 seconds every 2 minutes.
2. 6 mL of 0.01 N H_3PO_4 to the test tube, and the sample was agitated for 2 minutes on a wrist action shaker.
3. The organic layer was removed and the quantitation standard was added. The sample was concentrated in a Reacti-Vial at room temperature (using prepurified N_2) to 1 mL prior to GC/MS analysis.

Cleanup of the organic (or base/neutrals) layer from the first 0.5 N NaOH extraction involved successively washing the extract with concentrated H_2SO_4 and double-distilled water. The acid or water was added in a 20 mL portion and the sample was shaken for four minutes. After the aqueous (or acid) and organic layers were completely separated, the acid layer was discarded. The acid washing procedure was repeated until the acid layer was colorless. The organic fraction from the final wash was dried with anhydrous Na_2SO_4, exchanged to hexane and concentrated. Final cleanup of the sample by column chromatography involved the following procedure.

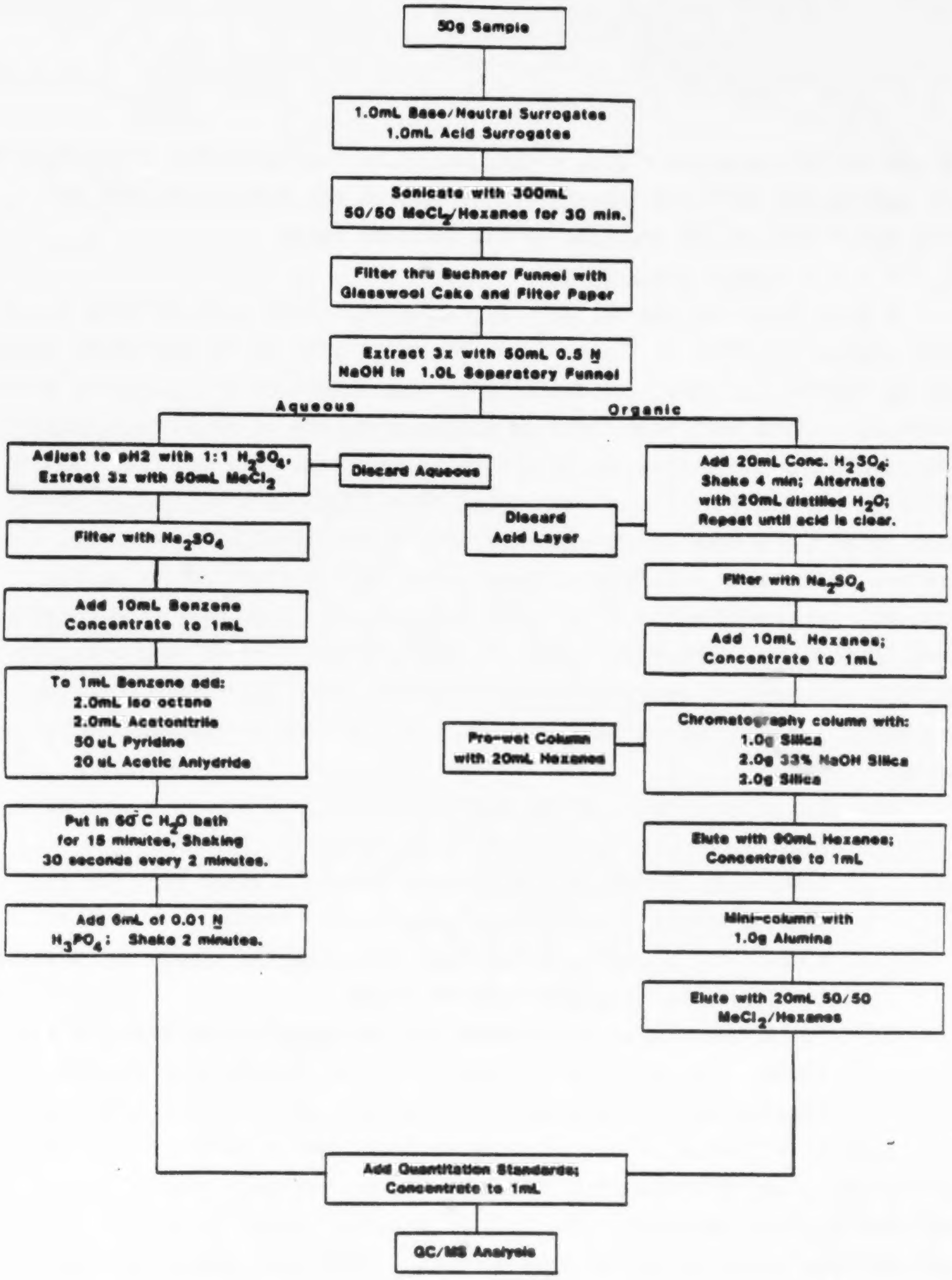

50g Sample
1.0mL Base/Neutral Surrogates
1.0mL Acid Surrogates
Sonicate with 300mL
50/50 $MeCl_2$/Hexanes for 30 min.
Filter thru Buchner Funnel with
Glasswool Cake and Filter Paper
Extract 3x with 50mL 0.5 N
NaOH in 1.0L Separatory Funnel
Aqueous
Organic
Adjust to pH2 with 1:1 H_2SO_4,
Extract 3x with 50mL $MeCl_2$
Discard Aqueous
Filter with Na_2SO_4
Add 10mL Benzene
Concentrate to 1mL
To 1mL Benzene add:
2.0mL Iso octane
2.0mL Acetonitrile
50 uL Pyridine
20 uL Acetic Anhydride
Put in 60°C H_2O bath
for 15 minutes, Shaking
30 seconds every 2 minutes.
Add 6mL of 0.01 N
H_3PO_4: Shake 2 minutes.
Add 20mL Conc. H_2SO_4;
Shake 4 min; Alternate
with 20mL distilled H_2O;
Repeat until acid is clear.
Discard
Acid Layer
Filter with Na_2SO_4
Add 10mL Hexanes;
Concentrate to 1mL
Pre-wet Column
with 20mL Hexanes
Chromatography column with:
1.0g Silica
2.0g 33% NaOH Silica
2.0g Silica
Elute with 90mL Hexanes;
Concentrate to 1mL
Mini-column with
1.0g Alumina
Elute with 20mL 50/50
$MeCl_2$/Hexanes
Add Quantitation Standards;
Concentrate to 1mL
GC/MS Analysis

Figure 7-1. Sample Preparation Flow Diagram for Site SSI - A Precursor Analyses

A glass macro-column, 20 mm o.d. x 230 mm in length, tapered to 6 mm o.d. on one end was prepared. The column was packed with a plug of silanized glass wool, followed successively by 1.0 g silica, 2.0 g silica containing 33% (w/w) 1 N NaOH, and 2.0 g silica. The concentrated extract was quantitatively transferred to the column and eluted with 90 mL hexane. The entire eluate was collected and concentrated to a volume of 1 mL in a centrifuge tube.

A disposable liquid chromatography mini-column was constructed by cutting off a 5-mL Pyrex disposable pipette at the 2.0 mL mark and packing the lower portion of the tube with a small plug of silanized glass wool, followed by 1 g of Woehlm basic alumina. The alumina had been previously activated for at least 16 hours at 600°C in a muffle furnace and cooled in a desiccator for 30 minutes just before use. The concentrated eluate from above was quantitatively transferred onto the liquid chromatography column. The centrifuge tube was rinsed consecutively with two 0.3-mL portions of a 3 percent $MeCl_2$: hexane solution, and the rinses were transferred to the liquid chromatography column.

The liquid chromatography column was eluted with 20 mL of a 50 percent (v/v) $MeCl_2$:hexane solution, and the eluate was concentrated to a volume of approximately 1 mL by heating the tubes in a water bath while passing a stream of prepurified N_2 over the solutions. The quantitation standard was added and the final volume was adjusted to 1.0 mL prior to GC/MS analysis.

7.2.1.2 Analysis

Analyses for CP, CB and PCBs present in the feed sample extracts were performed with a Finnigan Model 5100 mass spectrometer using selected ion monitoring. A fused silica capillary column was used for chromatographic separation of the compounds of interest. Analytical conditions for the GC/MS analysis are shown in Table 7-1.

Tuning of the GC/MS was performed daily as specified in the Tier 4 QA Project Plan. An internal-standard calibration procedure was used for sample quantitation. Compounds of interest were calibrated against a fixed concentration of either d_{12}-chrysene (for CB, PCB) or d_8-naphthalene (for CP). Components of the calibration solution are shown in Table 7-2. For multi-point calibrations, this solution was injected at levels of 10, 50, 100, and 150 ng/ul.

TABLE 7-1. INSTRUMENT CONDITIONS FOR GC/MS PRECURSOR ANALYSES

Parameter	Chlorobenzenes/ Polychlorinated biphenyls	Chlorophenols
Column	30 m WB DB-5 (1.0 u film thickness) fused silica capillary	
Injector Temperature	290°C	290°C
Separator Oven Temperature	290°C	290°C
Column Head Pressure	9 psi	9 psi
He flow rate	1 mL/min	1 mL/min
GC program	40(4)-290°C, 10°/min & hold	40(1)-290°C, 12°/min & hold
Emission Current	0.50 ma	0.50 ma
Electron Energy	70 ev	70 ev
Injection Mode	Splitless 0.6 min, then 10:1 split	
Mode	Electron ionization, Selected Ion Monitoring	

TABLE 7-2. COMPONENTS OF THE CALIBRATION SOLUTION

Base/Neutrals	Acids
4-chlorobiphenyl	2,5-dichlorophenol
3,3'-dichlorobiphenyl	2,3-dichlorophenol
2,4',5-trichlorobiphenyl	2,6-dichlorophenol
3,3'4,4'-tetrachlorobiphenyl	3,5-dichlorophenol
2,2',6,6'-tetrachlorobiphenyl	3,4-dichlorophenol
2,2,4,5,6-pentachlorobiphenyl	2,3,5-trichlorophenol
2,2',4,4',5,5'-hexachlorobiphenyl	2,3,6-trichlorophenol
2,2',3,4,4',5',6-heptachlorobiphenyl	3,4,5-trichlorophenol
2,2',3,3',4,4',5,5'-octachlorobiphenyl	2,4,5-trichlorophenol
2,2',3,3',4,4',5,6,6'-nonachlorobiphenyl	2,3,4-trichlorophenol
decachlorobiphenyl	2,3,5,6-tetrachlorophenol
p-dichlorobenzene	pentachlorophenol
1,2,4-trichlorobenzene	d_6-phenol (SS)
1,2,3,5-tetrachlorobenzene	d_4-2-chlorophenol (SS)
pentachlorobenzene	$^{13}C_6$-pentachlorophenol (SS)
hexachlorobenzene	d_8-naphthalene (QS)
d_4-1,4-dichlorobenzene (SS)[1]	2,4,6-tribromophenol (QS)
3-bromobiphenyl (SS)	d_{10}-phenanthrene (QS)
2,2',5,5'-tetrabromobiphenyl (SS)	d_{12}chrysene (QS)
2,2',4,4',6,6'-hexabromobiphenyl (SS)	
octachloronaphthalene (QS)[2]	
d_{10}-phenanthrene (QS)	
d_{12}-chrysene (QS)	

---

[1] Surrogate standard.

[2] Quantitation standard.

Compound identification was confirmed by comparison of chromatographic retention times and mass spectra of unknowns with retention times and mass spectra of reference compounds. Since the selected ion monitoring technique was necessary for the samples analyzed, care was taken to monitor a sufficiently wide mass region to avoid the potential for reporting false positives.

The instrument detection limit for the analytes of interest (CP, CB, and PCB) was estimated to be approximately 500 pg on column. For a 50 g sample and 100 percent recovery of the analyte, this corresponds to a feed sample detection limit of 10 ppb.

7.3 TOTAL CHLORINE ANALYSIS

Total chlorine concentrations in feed samples were determined by Parr Bomb combustion followed by ion chromatography (IC). A 0.5g sample was placed in the Parr Bomb with 10 mL of a 50 g/L Na_2CO_3 solution. After combustion of the samples according to standard procedures (ASTM 2015), the contents of the bomb were rinsed into a 100 mL flask and diluted to 100 mL. The resulting solution was analyzed for chloride concentration (Cl^-) by IC using standard anion conditions. For samples difficult to combust (such as sludges), 25 drops of paraffin oils were added to the bomb prior to combustion.

8.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

This section summarizes results of the quality assurance and quality control QA/QC activities for field sampling and laboratory analyses for Site SSI-A. The scrubber outlet flue gas and bottom ash dioxin/furan data for Site SSI-A were within the QC specifications presented in the Tier 4 QAPP. Surrogate recoveries for all the samples were well within the specified limits of 50 to 120 percent for labeled TCDD's and 40 to 120 percent for hepta- and octa-CDD's. Surrogate recoveries for the incinerator outlet data were all 32 percent or less. The laboratory reported that the sample extracts were yellow in color and they destroyed the capillary column resolution. No quantitative dioxin/furan data were obtained for these samples. The results of the analysis of the fortified laboratory QC sample were within 40 percent of true values for all homologues. The dioxin/furan data presented in this report were well within the accuracy objectives of the Tier 4 program.

The dioxin/furan precursor analysis of the feed samples was not as accurate as the dioxin/furan homologue analysis. Surrogate recoveries of the base neutral fraction were generally within the specified QC limits of 100 ± 50 percent; however, the surrogate acid fraction recoveries were well below the QC limits. This trend was noticed in the analysis of nearly all Tier 4 feed samples. In spite of the low recoveries of the acid fraction, the dioxin/furan precursor results are considered a reasonable approximation of the true precursor concentration in the feed samples.

The following sections summarize the results of all Site SSI-A QA/QC activities. Manual gas sampling methods are considered in Section 8.1 and continuous monitoring and molecular weight determinations are considered in Section 8.2 The laboratory analysis QA/QC activities are summarized in Section 8.3.

8.1 MANUAL GAS SAMPLING

Manual gas sampling methods at Site SSI-A included Modified Method 5 (MM5), EPA Methods 1 through 4, and the ambient air/XAD sampling train. These methods are discussed in Section 6.0. Quality assurance and quality control (QA/QC) activities for the manual sampling methods centered around (1) equipment calibration, (2) glassware pre-cleaning, (3) procedural QC checks and (4) sample custody procedures. Key activities and QC results in each of these areas are discussed in this section. Also discussed are problems encountered that may have affected data quality.

Pre-test calibrations or inspections were conducted on pitot tubes, sampling nozzles, temperature sensors and analytical balances. Both pre-test and post-test calibrations were performed on the dry gas meters. All of the field test equipment met the calibration criteria specified in the Tier 4 Quality Assurance Project Plan (QAPP). Differences in the pre-test and post-test dry gas meter calibrations were less than 2 percent.

An extensive pre-cleaning procedure was used for all sample train glassware and sample containers. This cleaning procedure, which is outlined in Table 8-1, was implemented to minimize the potential for sample contamination with substances that could interfere with the dioxin/furan analysis. To minimize the potential for contamination in the field, all sample train glassware was capped with foil prior to use and stored in a dust-controlled environment. A sample trailer was maintained for the specific purpose of sample train assembly and recovery.

Prior to leaving for the test site, a potential contamination problem was identified during inspection of the sample containers (after precleaning procedures had been instituted). Spots were observed on some amber glassware and sampling glassware. The spots were removed by wiping with clean Kimwipes. A randomly selected set of glassware and sample containers were rinsed with the solvents anticipated for use in the field recovery procedure, and the rinse was submitted to the Radian-RTP laboratory for future potential analyses.

Procedural QA activities during the manual gas sampling focused on:

- visual equipment inspections,
- utilization of sample train blanks,
- ensuring the proper location and number of traverse points,
- conducting pre-test and post-test sample train leak checks,
- maintaining proper temperature at the filter housing, sorbent trap and impinger train,
- maintaining isokinetic sampling rates, and
- recording all data on preformatted field data sheets.

TABLE 8-1. GLASSWARE PRECLEANING PROCEDURE

NOTE: USE DISPOSABLE GLOVES AND ADEQUATE VENTILATION

1. Soak all glassware in hot soapy water (Alconox^R) 50°C or higher.
2. Distilled/deionized H_2O rinse (X3).[a]
3. Distilled/deinoized H_2O rinse (X3).
4. Chromerge^R rinse if glass, otherwise skip to 6.
5. High purity liquid chromatography grade H_2O rinse (X3).
6. Acetone rinse (X3), (pesticide grade).
7. Hexane rinse (X3), (pesticide grade).
8. Oven dry (110°C - 2 hrs).
9. Cap glassware with clean glass plugs or hexane rinsed aluminum foils.

---

[a] (X3) = three times.

During sampling Run 09 at the incinerator outlet location, the condenser coil prior to the XAD sorbent module became discolored. Upon completion of the sampling run and disassembly of the sample train, it was determined that the discoloration in the coil and condenser was due to a torn filter. This allowed a small amount of particulate to bypass the filter and and enter the sorbent module. No unusual discoloration was observed in the impingers for this run.

Results of the isokinetic calculations for the MM5 test runs are shown in Table 8-2. The average isokinetc sampling rate for each MM5 sampling run was within the QA objective of 100 ± 10 percent (%), except for Run 11 at the incinerator outlet location, which was 111.8 percent isokinetic.

Blank sample trains were used at both MM5 sample locations to determine the background levels of contaminants that might interfere with dioxin and furan analysis. Blank sample trains were treated as normal samples. Trains were assembled completely and transported to the respective sample location. Recovery of the blank trains was performed in the same sequence as for a normal test run. All solvents used in the recovery of blanks came from the same container as for normal test runs. The sample blank for the scrubber outlet location was contaminated during recovery and was not submitted to Troika for analysis. The incinerator outlet sample blank was submitted for analysis, and these results are discussed in Section 8.3.1.2.

Initial final and port change leak checks for the MM5 sample trains were acceptable for all of the test runs. None of the reported sample volumes required correction for sample train leakage. Leak check data were recorded on the MM5 field data sheets.

Sample custody procedures used during this program emphasized careful documentation of the samples collected and the use of chain-of-custody records for samples transported to the laboratory for analysis. Steps taken to identify and document samples included labeling each sample with a unique alphanumeric code and logging the sample in a mass logbook. All samples shipped to Troika or return to Radian/RTP were also logged on chain-of-custody records that were signed by the field sample custodian upon shipment and also signed upon receipt at the laboratory. Each sample container lid was individually sealed to ensure that samples were not tampered with. No

TABLE 8-2. SUMMARY OF ISOKINETICS RESULTS FOR MM5 SAMPLING TRAINS

Run	Scrubber Outlet	Meets QC Objective[a]	Incinerator Outlet	Meets QC Objective[a]
09	95.6	Yes	96.8	Yes
10	94.7	Yes	99.9	Yes
11	103.4	Yes	111.8	No

[a] The quality assurance objective for MM5 sampling was isokinetics of 100± 10 percent.

evidence of loss of sample integrity was reported for samples collected at this site.

8.2 CONTINUOUS MONITORING/MOLECULAR WEIGHT DETERMINATION

Flue gas parameters measured continuously during the MM5 test runs include CO, CO_2, O_2 total hydrocarbons (THC) and SO_x and NO_x. The concentrations of O_2, CO_2 and nitrogen (N_2) were also determined for integrated bag samples of the flue gas. Quality control results for these analyses are discussed in this section.

Drift check results for the continuously monitored flue gas parameters are summarized in Table 8-3. The acceptance criteria for drift checks was a daily instrument drift within ± 10 percent. Data prediction was performed by assuming a linear drift of the instrument response over the test day based on drift checks art the beginning and end of the day. The largest calibration drifts were observed for the NO_x analyzer, which exceeded QC target goals for two test runs. The smallest instrument drift was observed for the oxygen monitor.

The quality control standards for this program consisted of mid-range concentration standards that were not intended to be used for instrument calibration. The intention was to analyze the QC gases immediately after calibration each day to provide data on day-to-day instrument variability. The acceptance criteria for the analysis of each QC standard was agreement within ±10 percent of the running mean value. However, the QC gases were not used for this purpose at Site SSI-A. A leak in the sample gas manifold resulted in the loss of several of the gas cylinders originally intended for use as calibration span gases. Consequently, the QC gases were used as calibration span gases and could not be used for their original purpose.

Molecular weight was determined by analyzing integrated bag samples of flue gas for CO_2, O_2, and N_2. Quality control for this analysis involved duplicate analyses of calibration gases immediately before and after sample analysis. Analysis of the calibration gases was repeated until two consecutive analyses agreed to within ±5 percent. This same criteria of ±5 percent applied to duplicate analyses required for sample quantification. These criteria were met for all molecular weight determinations.

TABLE 8-3. DAILY DRIFT CHECK RESULTS FOR CONTINUOUS MONITORS

Parameter	Test Date	Test Run	Input Concentration	Instrument Drift[a] (%)	Meets QC?[b]
O_2	10/8/84	09	9.0% vol	0.2	Yes
O_2	10/9/84	10	9.0% vol	0.5	Yes
O_2	10/10/84	11	9.0% vol	-0.2	Yes
CO	10/8/84	09	1000 ppmv	4.8	Yes
CO	10/9/84	10	1000 ppmv	4.5	Yes
CO	10/10/84	11	1000 ppmv	-4.4	Yes
CO_2	10/8/84	09	12.0% vol	2.1	Yes
CO_2	10/9/84	10	12.0% vol	-15.5	No
CO_2	10/10/84	11	12.0% vol	-0.7	Yes
SO_2	10/8/84	09	80 ppmv	4.8	Yes
SO_2	10/9/84	10	80 ppmv	7.3	Yes
SO_2	10/10/84	11	80 ppmv	14.8	No
NO_x	10/8/84	09	152 ppmv	39.6	No
NO_x	10/9/84	10	152 ppmv	4.2	Yes
NO_x	10/10/84	11	152 ppmv	37.0	No
THC	10/8/84	09	444 ppmv	0.1	Yes
THC	10/9/94	10	444 ppmv	5.4	Yes
THC	10/10/84	11	444 ppmv	4.2	Yes

[a] Instrument drift is defined as the percent difference between the instrument calibration factors calculated at the beginning and end of each test run.

[b] Quality control objective was daily instrument drift less than ±10 percent.

8.3 LABORATORY ANALYSES

QA/QC activities were carried out for dioxin/furan and precursor analyses performed on Site SSI-A samples. The dioxin/furan analyses of MM5 train samples and bottom ash samples performed by Troika are considered in Section 8.3.1. The precursor analyses of the sludge feed samples performed by Radian/RTP are considered in Section 8.3.2.

8.3.1 Dioxin/Furan Analyses

Two individual topics related to the dioxin/furan analyses at Site SSI-A are discussed in this section. Analytical recoveries of labeled surrogate compounds spiked onto MM5 train samples are reported in Section 8.3.1.1. Sample blank data are reported in Section 8.3.1.2.

8.3.1.1 Surrogate Recoveries of the Test Samples

Table 8-4 presents the analytical recovery data reported by Troika for the isotopically labeled surrogate compounds spiked onto the primary MM5 train samples and bottom ash samples. Those samples consisting solely of solid components, such as bottom ash, were spiked with $^{13}C_{12}$-TCDD and $^{13}C_{12}$-octa-CDD surrogates. Samples that consisted of both solid and liquid components, such as the primary MM5 train samples, were spiked with four surrogates, $^{37}Cl_4$-TCDD, $^{13}C_{12}$-TCDD, $^{37}Cl_4$-hepta CDD, and $^{13}C_{12}$-octa CDD.

Surrogate recoveries for the bottom ash samples ranged from 78 to 90 percent for the labeled TCDD and from 86 to 91 percent for the labeled octa-CDD. Recoveries for the primary MM5 train samples from the scrubber outlet ranged from 96 to 100 percent for the labeled TCDDs and from 76 and 89 percent for the labeled hepta- and octa- CDDs. These recovery values were within the QA targets of 40 to 120 percent recovery for the labeled TCDD species and 40 to 120 percent recovery for the labeled hepta- and octa-CDD species.

Surrogate recoveries for the incinerator outlet MM5 train samples were reported to be zero for all four species for Run 09 and to be below 32 percent for all species for Run 10. No recovery data were reported for incinerator outlet MM5 samples for Run 11. The Troika laboratory report noted that the Run 09 and Run 10 samples destroyed the capillary column resolution. Thus, no valid dioxin/furan analytical data were obtained for the incinerator outlet MM5 samples.

TABLE 8-4. PERCENT SURROGATE RECOVERIES FOR SITE SSI-A DIOXIN/FURAN ANALYSES (OUTLET)

Sample	$^{37}Cl_4$ TCDD	$^{13}C_{12}$ TCDD	$^{37}Cl_4$ Hepta-CDD	$^{13}C_{12}$ Octa-CDD
Incinerator Outlet MM5 Train Samples				
Run 09 MM5	0	0	0	0
Run 10 MM5	32	28	NR	14
Run 11 MM5	NR	NR	NR	NR
Scrubber Outlet MM5 Train Samples				
Run 09 MM5	98	100	89	89
Run 10 MM5	100	98	85	83
Run 11 MM5	96	100	84	76
Bottom Ash Samples				
Run 09	90	-	-	91
Run 10	82	-	-	88
Run 11	78	-	-	86

Dash (-) indicates that the surrogate compound of interest was not spiked onto this sample.
NR = not reported by Troika.

8.3.1.2 Sample Blanks

Table 8-5 summarizes the analytical results reported by Troika for internal laboratory blanks, laboratory fortified quality control (QC) samples, and the inlet field recovery blank MM5 train samples. Proof blank MM5 train samples were not provided for Site SSI-A because the practice of submitting proof train samples was not developed until later in the Tier 4 program. The outlet field recovery blank for the MM5 train samples was not submitted to Troika due to known field contamination. The surrogate recovery values for both the flue gas QC samples and bottom ash QC samples ranged from 64 to 97 percent. Detectable quantities of both octa-CDD (0.11 nanograms) and octa-CDF (0.54 nanograms) were found in the internal laboratory blank. Measured values for the laboratory fortified QC sample were within the ± 40 percent of the true values, which satisfies the QA objective of ± 50 percent accuracy.

Table 8-6 gives a comparison of the dioxin/furan analytical results for the inlet field blank MM5 train and the scrubber outlet test run MM5 trains. The data show that relative to the scrubber outlet MM5 train values, the inlet field blank contained significant quantities of hepta- and octa- CDD/DCF. However, the inlet field blank did not contain detectable quantities of the tetra-chlorinated species, which were the most prevalent species in the MM5 test run samples.

8.3.2 Precursor Analyses

Table 8-7 presents analytical recovery efficiencies for seven isotopically labeled compounds used as surrogates for the target precursor analytes in the Site SSI-A feed samples. The surrogate recovery values in Table 8-7 vary considerably by specific surrogate species but are fairly uniform between runs for the same species. The surrogate recoveries ranged from 11 percent for $^{13}C_6$-pentachlorophenol to 88 percent for bromobiphenyl. Several of the recoveries are below the 50 percent objective stated in the Tier 4 QA Project Plan and are below those generally considered achievable when analyzing for similar compounds in water or from MM5 train components.

TABLE 8-5. ANALYSIS RESULTS FOR QUALITY CONTROL SAMPLES

	Flue Gas Quality Control Samples				
		Fortified Laboratory QC Sample		Field Blank MM5 Train	
Compound	Laboratory Blank	Measured Value	True Value[a,b]	Inlet	Outlet
	Amount Detected (Nanograms per Sample)				
Dioxins					
2378 TCDD	ND	.35	0.4 (-13)	ND	NS
Other TCDD	NR	ND	ND (0)	ND	NS
Penta CDD	ND	ND	ND (0)	ND	NS
Hexa CDD	ND	.98	1.6 (-39)	ND	NS
Hepta CDD	ND	2.6	2.4 (+8)	1.7	NS
Octa CDD	.11	2.7	3.2 (-16)	18.5	NS
Furans					
Total TCDF	ND	.34	0.4 (-15)	ND	NS
Penta CDF	ND	.75	0.8 (-6)	ND	NS
Hexa CDF	ND	1.9	1.6 (+19)	ND	NS
Hepta CDF	ND	2.1	2.4 (-13)	1.9	NS
Octa CDF	.54	3.1	3.2 (-3)	3.4	NS
	Surrogate Recoveries (Percent)				
$^{37}Cl_4$-TCDD	94	86	NA	86	-
$^{13}C_{12}$-TCDD	96	86	NA	96	64
$^{37}Cl_4$-Hepta CDD	97	86	NA	83	-
$^{13}C_{12}$-Octa CDD	88	90	NA	89	85

[a] True values represent the amounts of each homologue spiked into the laboratory fortified QC samples.

[b] Value shown in parenthesis is the percentage difference between the measured value and the true value:

$$\%\text{difference} = \frac{\text{Measured Value} - \text{True Value}}{\text{True Value}} \times 100$$

ND = Not detected.
NR = Not reported by Troika.
NS = Not sampled.
NA = Not applicable.
Dash(-) indicates that the surrogate compound of interest was not spiked onto this sample.

TABLE 8-6. FIELD BLANK DIOXIN/FURAN DATA FOR SITE SSI-A MM5 SAMPLES

Isomer/ Homologue	Scrubber Inlet		Scrubber Outlet	
	Amount Detected ng/train			
	Field Blank Value	Minimum Test Run Value	Field Blank Value	Minimum Test Run Value
Dioxins				
2378-TCDD	ND	NR	NS	0.03
Other TCDD	ND	NR	NS	8.3
Penta CDD	ND	NR	NS	0.13
Hexa CDD	ND	NR	NS	0.66
Hepta CDD	1.7	NR	NS	1.8
Octa CDD	18.5	NR	NS	3.3
Furans				
Total TCDF	ND	NR	NS	26.4
Penta CDF	ND	NR	NS	7.6
Hexa CDF	ND	NR	NS	0.44
Hepta CDF	1.9	NR	NS	0.37
Octa CDF	3.4	NR	NS	0.22

ND = Not detected.

NR = Not reported by Troika. Method efficiencies for the incinerator outlet (scrubber inlet) were below the Tier 4 QA/QC criteria.

NS = Not submitted to Troika for analysis. The outlet field blank train was contaminated on-site during preparation.

TABLE 8-7. PERCENT SURROGATE RECOVERIES FOR SITE SSI-A FEED SAMPLES

Surrogate Compound	Percent Surrogate Recovery Sludge Feed Samples			
	Run 09	Run 10	Run 11	Average
Base Neutrals Fraction				
d_4-dichlorobenzene	60	28	31	40
bromobiphenyl	99	73	91	88
2', 5, 5' tetra bromobiphenyl	81	75	74	77
2', 4, 4', 6, 6' hexabromobiphenyl	ND	23	ND	ND
Acids Fraction				
d_6-phenol	12	16	10	13
d_4-2-chlorophenol	26	31	18	25
$^{13}C_6$-pentachlorophenol	13	12	7	11

ND = Not detected.

APPENDIX A
FIELD RESULTS

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APPENDIX A.1

MODIFIED METHOD 5
and
EPA METHODS 1-4 FIELD RESULTS

APPENDIX A.1.1

Scrubber Outlet
MM5 Sampling Data

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```
     R A D I A N   S O U R C E   T E S T
     E P A   M E T H O D   2 - 5
     ( R A W   D A T A )
   PLANT                  : SITE 01
   PLANT SITE             :
   SAMPLING LOCATION      : SCRUBBER EXHAUST "A"
   TEST #                 : HR-A-9
   DATE                   : 10/08/84
   TEST PERIOD            : 1500-1920

 PARAMETER                                  VALUE
 ---------                                  -----

 Sampling time (min.)                        240
 Barometric Pressure (in.Hg)                 30.4
 Sampling nozzle diameter (in.)              .486
 Meter Volume (cu.ft.)                       215.641
 Meter Pressure (in.H2O)                     2.89
 Meter Temperature (F)                       95.8
 Stack dimension (sq.in.)                    1734.949
 Stack Static Pressure (in.H2O)              .03
 Stack Moisture Collected (gm)               98.85
 Absolute stack pressure(in Hg)              30.40221
 Average stack temperature (F)               161
 Percent CO2                                 2.31
 Percent O2                                  18.74
 Percent N2                                  78.95
 Delps Subroutine result                     5.751807
 DGM Factor                                  .9959
 Pitot Constant                              .84
```

```
   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D S   2 - 5
   F I N A L   R E S U L T S
PLANT                 : SITE 01
PLANT SITE            :
SAMPLING LOCATION     : SCRUBBER EXHAUST "A"
TEST #                : HR-A-9
DATE                  : 10/08/84
TEST PERIOD           : 1500-1920

    PARAMETER                  RESULT
    ---------                  ------

    Vm(dscf)                    208.7371
    Vm(dscm)                    5.911435
    Vw gas(scf)                 4.660778
    Vw gas (scm)                .1319932
    % moisture                  2.184079
    Md                          .9781592
    MWd                         29.1192
    MW                          28.87635
    Vs(fpm)                     836.4242
    Vs (mpm)                    255.0074
    Flow(acfm)                  10077.45
    Flow(acmm)                  285.3935
    Flow(dscfm)                 8516.207
    Flow(dscmm)                 241.179
    % I                         95.57008
    % EA                        891.1934



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```

```
        R A D I A N   S O U R C E   T E S T
        E P A   M E T H O D   2 - 5
        ( R A W   D A T A )
     PLANT                  : SITE 01
     PLANT SITE             :
     SAMPLING LOCATION      : SCRUBBER EXHAUST "A"
     TEST #                 : HR-A-10
     DATE                   : 10/09/84
     TEST PERIOD            : 1336-1750

  PARAMETER                                 VALUE
  ---------                                 -----

  Sampling time (min.)                       240
  Barometric Pressure (in.Hg)               30.3
  Sampling nozzle diameter (in.)            .486
  Meter Volume (cu.ft.)                     219.47
  Meter Pressure (in.H2O)                   3.03
  Meter Temperature (F)                     103.2
  Stack dimension (sq.in.)                  1734.949
  Stack Static Pressure (in.H2O)            .03
  Stack Moisture Collected (gm)             85.1
  Absolute stack pressure(in Hg)            30.30221
  Average stack temperature (F)             181.1667
  Percent CO2                               2.26
  Percent O2                                18.89
  Percent N2                                78.85
  Delps Subroutine result                   5.994091
  DGM Factor                                .9959
  Pitot Constant                            .84
```

```
      RADIAN SOURCE TEST
      EPA METHODS 2-5
      FINAL RESULTS
PLANT                 : SITE 01
PLANT SITE            :
SAMPLING LOCATION     : SCRUBBER EXHAUST "A"
TEST #                : HR-A-10
DATE                  : 10/09/84
TEST PERIOD           : 1336-1750

   PARAMETER                      RESULT
   ---------                      ------

   Vm(dscf)                        209.0378
   Vm(dscm)                        5.919951
   Vw gas(scf)                     4.012465
   Vw gas (scm)                    .113633
   % moisture                      1.883342
   Md                              .9811666
   MWd                             29.1172
   MW                              28.90782
   Vs(fpm)                         872.6186
   Vs (mpm)                        266.0423
   Flow(acfm)                      10513.53
   Flow(acmm)                      297.7433
   Flow(dscfm)                     8603.34
   Flow(dscmm)                     243.6466
   % I                             94.73842
   % EA                            980.5859


                                     Program Revision:1/16/84
   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D   2 - 5
   ( R A W   D A T A )
PLANT                : SITE 01
PLANT SITE           :
SAMPLING LOCATION    : SCRUBBER EXHAUST "A"
TEST #               : HR-A-11
DATE                 : 10/10/84
TEST PERIOD          : 1030-1530 (UPSET: 1400-1450)

PARAMETER                              VALUE
---------                              -----

Sampling time (min.)                   240
Barometric Pressure (in.Hg)            30.42
Sampling nozzle diameter (in.)         .486
Meter Volume (cu.ft.)                  215.16
Meter Pressure (in.H2O)                2.97
Meter Temperature (F)                  85.5
Stack dimension (sq.in.)               1734.949
Stack Static Pressure (in.H2O)         .03
Stack Moisture Collected (gm)          402.8
Absolute stack pressure(in Hg)         30.42221
Average stack temperature (F)          176.625
Percent CO2                            3
Percent O2                             16.75
Percent N2                             80.25
Delps Subroutine result                5.838538
DGM Factor                             .9959
Pitot Constant                         .84
```

```
      R A D I A N   S O U R C E   T E S T
      E P A   M E T H O D S   2 - 5
      F I N A L   R E S U L T S
PLANT                 : SITE 01
PLANT SITE            :
SAMPLING LOCATION     : SCRUBBER EXHAUST "A"
TEST #                : HR-A-11
DATE                  : 10/10/84
TEST PERIOD           : 1030-1530 (UPSET: 1400-1450)

     PARAMETER                    RESULT
     ---------                    ------

     Vm(dscf)                      212.3835
     Vm(dscm)                      6.014699
     Vw gas(scf)                   18.99202
     Vw gas (scm)                  .537854
     % moisture                    8.208312
     Md                            .9179169
     MWd                           29.15
     MW                            28.23477
     Vs(fpm)                       858.346
     Vs (mpm)                      261.6909
     Flow(acfm)                    10341.57
     Flow(acmm)                    292.8734
     Flow(dscfm)                   8005.148
     Flow(dscmm)                   226.7058
     % I                           103.4475
     % EA                          377.5924




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```

APPENDIX A.1.2

Incinerator Outlet (Scrubber Inlet)
MM5 Sampling Data

```
     R A D I A N   S O U R C E   T E S T
     E P A   M E T H O D   2 - 5
     ( R A W   D A T A )
  PLANT                  : SITE 01
  PLANT SITE             :
  SAMPLING LOCATION      : SCRUBBER INLET "B"
  TEST #                 : HR-B-9
  DATE                   : 10/08/84
  TEST PERIOD            : 1500-1934

PARAMETER                                VALUE
---------                                -----

Sampling time (min.)                      270
Barometric Pressure (in.Hg)               30.4
Sampling nozzle diameter (in.)            .497
Meter Volume (cu.ft.)                     158.583
Meter Pressure (in.H2O)                   1.26
Meter Temperature (F)                     107.4
Stack dimension (sq.in.)                  1188
Stack Static Pressure (in.H2O)           -.1
Stack Moisture Collected (gm)             1166
Absolute stack pressure(in Hg)            30.39265
Average stack temperature (F)             746.3334
Percent CO2                               7.4
Percent O2                                12.2
Percent N2                                80.6
Delps Subroutine result                   8.632847
DGM Factor                                .9959
Pitot Constant                            .84
```

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     R A D I A N   S O U R C E   T E S T
     E P A   M E T H O D S   2 - 5
     F I N A L   R E S U L T S
PLANT                   : SITE 01
PLANT SITE              :
SAMPLING LOCATION       : SCRUBBER INLET "B"
TEST #                  : HR-B-9
DATE                    : 10/08/84
TEST PERIOD             : 1500-1934

     PARAMETER                    RESULT
     ---------                    ------

     Vm(dscf)                      149.7788
     Vm(dscm)                      4.241737
     Vw gas(scf)                   54.9769
     Vw gas (scm)                  1.556946
     % moisture                    26.85
     Md                            .7315
     MWd                           29.728
     MW                            26.57903
     Vs(fpm)                       1308.718
     Vs (mpm)                      398.9993
     Flow(acfm)                    10796.92
     Flow(acmm)                    305.7688
     Flow(dscfm)                   3511.461
     Flow(dscmm)                   99.44456
     % I                           96.79835
     % EA                          134.3849




                                          Program Revision:1/16/84
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   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D   2 - 5
   ( R A W   D A T A )
  PLANT                : SITE 01
  PLANT SITE           :
  SAMPLING LOCATION    : SCRUBBER INLET "B"
  TEST #               : HR-B-10
  DATE                 : 10/09/84
  TEST PERIOD          : 1335-1814

PARAMETER                              VALUE
---------                              -----

Sampling time (min.)                    270
Barometric Pressure (in.Hg)             30.3
Sampling nozzle diameter (in.)          .495
Meter Volume (cu.ft.)                   168.37
Meter Pressure (in.H2O)                 1.4
Meter Temperature (F)                   114.9
Stack dimension (sq.in.)                1188
Stack Static Pressure (in.H2O)         -.12
Stack Moisture Collected (gm)           1265.4
Absolute stack pressure(in Hg)          30.29118
Average stack temperature (F)           811.4445
Percent CO2                             5
Percent O2                              15.3
Percent N2                              79.7
Delps Subroutine result                 9.344061
DGM Factor                              .9959
Pitot Constant                          .84
```

```
      R A D I A N   S O U R C E   T E S T
      E P A   M E T H O D S   2 - 5
      F I N A L   R E S U L T S
PLANT                : SITE 01
PLANT SITE           :
SAMPLING LOCATION    : SCRUBBER INLET "B"
TEST #               : HR-B-10
DATE                 : 10/09/84
TEST PERIOD          : 1335-1814

      PARAMETER                RESULT
      ---------                ------

      Vm(dscf)                  156.4862
      Vm(dscm)                  4.431689
      Vw gas(scf)               59.66361
      Vw gas (scm)              1.689673
      % moisture                27.6029
      Md                        .723971
      MWd                       29.412
      MW                        26.26196
      Vs(fpm)                   1427.447
      Vs (mpm)                  435.1972
      Flow(acfm)                11776.44
      Flow(acmm)                333.5086
      Flow(dscfm)               3584.479
      Flow(dscmm)               101.5124
      % I                       99.87521
      % EA                      266.5135


                                        Program Revision:1/16/84
```

```
    R A D I A N   S O U R C E   T E S T
    E P A   M E T H O D   2 - 5
    ( R A W   D A T A )
  PLANT               : SITE 01
  PLANT SITE          :
  SAMPLING LOCATION   : SCRUBBER INLET "B"
  TEST #              : HR-B-11
  DATE                : 10/10/84
  TEST PERIOD         : 1033-1603 STOPPED FOR UPSET 1358-1453

PARAMETER                             VALUE
---------                             -----

Sampling time (min.)                   270
Barometric Pressure (in.Hg)            30.42
Sampling nozzle diameter (in.)         .495
Meter Volume (cu.ft.)                  146.034
Meter Pressure (in.H2O)                .97
Meter Temperature (F)                  106.2
Stack dimension (sq.in.)               1188
Stack Static Pressure (in.H2O)        -.12
Stack Moisture Collected (gm)          1387.9
Absolute stack pressure(in Hg)         30.41118
Average stack temperature (F)          829.4445
Percent CO2                            5.44
Percent O2                             14.03
Percent N2                             80.53
Delps Subroutine result                7.844025
DGM Factor                             .9888
Pitot Constant                         .84
```

```
   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D S   2 - 5
   F I N A L   R E S U L T S
PLANT                : SITE 01
PLANT SITE           :
SAMPLING LOCATION    : SCRUBBER INLET "B"
TEST #               : HR-B-11
DATE                 : 10/10/84
TEST PERIOD          : 1033-1603 STOPPED FOR UPSET 1358-1453

   PARAMETER                 RESULT
   ---------                 ------

   Vm(dscf)                   137.2275
   Vm(dscm)                   3.886283
   Vw gas(scf)                65.43948
   Vw gas (scm)               1.853246
   % moisture                 32.28917
   Md                         .6771083
   MWd                        29.4316
   MW                         25.74043
   Vs(fpm)                    1207.982
   Vs (mpm)                   368.2872
   Flow(acfm)                 9965.849
   Flow(acmm)                 282.2329
   Flow(dscfm)                2808.506
   Flow(dscmm)                79.53688
   % I                        111.7824
   % EA                       194.0547



                                          Program Revision:1/16/84
```

APPENDIX A.2

CONTINUOUS EMISSION MONITORING (CEM)
(O_2, CO, CO_2, SO_2, NO_x, THC)
FIELD RESULTS

CEM TEST RESULTS

CEMS DATA - SITE 01 - TEST 9

TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	SO2 (PPMV)	NOX (PPMV)	THC (PPMV)
1430	11.4	1381.9	13.4	524.5	172.1	77.7
1435	11.9	1439.7	13.6	509.1	177.9	74.4
1440	11.7	1422.1	13.4	526.4	172.4	77.8
1445	11.3	1304.9	13.8	564.6	161.8	81.3
1450	12.0	1591.5	12.4	488.3	155.5	96.4
1455	12.4	1613.9	12.4	497.0	158.9	215.7
1500	13.2	1461.7	11.1	433.3	151.1	251.4
1505	12.7	1478.5	12.1	458.9	151.3	229.2
1510	12.8	1447.0	11.9	467.8	157.4	166.0
1515	12.9	1413.2	11.2	424.4	149.2	48.1
1520	12.2	1445.6	12.6	512.9	158.3	245.3
1525	12.6	1395.9	11.6	452.8	151.4	108.5
1530	12.9	1568.1	11.6	442.8	160.0	209.2
1535	12.5	1560.5	12.1	465.5	157.2	132.3
1540	13.1	1391.3	11.1	423.0	157.8	187.4
1545	12.8	1416.3	11.4	458.6	159.9	171.8
1550	13.0	1446.6	11.0	417.9	162.3	219.2
1555	12.4	1493.6	12.0	482.0	159.4	205.2
1600	13.3	1383.3	10.7	382.7	157.5	212.0
1605	13.3	1505.0	10.8	419.1	174.4	166.6
1610	13.0	1395.7	11.1	420.3	168.7	237.3
1615	12.3	1376.3	11.8	456.3	158.3	224.8
1620	13.3	1436.0	11.0	391.4	173.5	286.8
1625	12.5	1548.2	12.1	471.4	171.4	242.4
1630	11.8	1497.7	12.9	517.3	171.4	102.5
1635	12.7	1385.9	11.2	422.0	157.9	170.3
1640	12.8	1480.5	11.3	422.3	166.8	207.2
1645	12.8	1618.8	11.7	443.6	178.7	241.1
1650	11.7	1616.8	13.5	517.8	184.1	156.7
1655	11.1	1566.3	13.7	549.7	173.5	125.2
1700	12.2	1508.9	12.2	483.0	171.3	185.9
1705	11.8	1502.0	13.2	519.8	176.8	191.4
1710	11.8	1502.5	12.8	485.1	169.8	170.7
1715	12.1	1576.8	12.5	484.0	174.2	75.7
1720	11.6	1551.2	12.9	513.3	172.0	106.1
1725	12.6	1290.2	11.6	448.5	171.4	168.6
1730	12.6	1371.3	11.9	461.6	172.6	141.9
1735	12.7	1351.0	11.6	458.3	174.6	157.9
1740	12.2	1340.3	12.1	495.8	173.7	74.2
1745	12.0	1439.2	12.4	522.9	189.8	164.5
1750	11.6	1347.0	13.2	538.8	186.3	101.2
1755	11.5	1386.7	13.5	583.6	181.1	70.9
1800	11.6	1317.6	13.1	541.1	173.0	64.5
1805	12.0	1294.0	13.0	500.3	183.7	105.5
1810	12.1	1306.6	12.4	482.2	172.5	119.8
1815	12.4	1378.4	11.8	459.7	185.7	140.7
1820	12.3	1394.9	12.2	492.3	198.7	172.3
1825	12.4	1315.0	12.0	460.2	189.0	149.0
1830	13.0	1334.9	11.2	421.1	190.0	155.1
1835	13.3	1488.4	10.8	403.7	203.6	170.0
1840	13.2	1428.2	10.7	413.3	203.4	85.4
1845	13.0	1411.0	11.1	423.5	204.2	156.7
1850	12.8	1332.2	11.5	439.8	210.4	91.0
1855	12.5	1295.4	11.7	458.2	209.2	188.9
1900	12.5	1450.7	11.8	469.6	213.5	167.2
1905	12.5	1404.0	11.4	447.1	217.3	88.2
1910	12.2	1373.0	12.0	485.0	207.7	160.7
1915	11.8	1417.4	12.8	535.8	212.9	162.1
1920	10.1	1755.2	15.6	697.9	258.7	119.6
1925	9.8	1709.2	15.3	688.9	239.9	61.3
1930	8.4	2131.0	17.3	858.8	304.6	89.0
1935	9.4	1373.4	15.2	683.1	235.4	58.6
1940	11.1	1060.8	13.3	565.4	199.3	29.5
1945	11.4	1196.3	13.2	579.6	214.9	35.6
1950	11.5	1079.4	12.9	529.8	200.0	19.5
1955	11.2	989.8	13.1	555.4	193.7	26.8
2000	11.7	1148.1	12.7	528.5	211.5	33.7
2005	11.9	1048.2	12.6	515.0	209.6	34.1
2010	11.8	1050.4	12.8	524.3	201.2	25.4
2015	11.5	1041.5	12.8	534.4	204.2	17.3
2020	11.5	1153.2	13.3	539.3	216.4	28.0
2025	12.2	1090.7	12.2	496.1	212.9	15.7
NO. PTS.	72	72	72	72	72	72
MEAN	12.1	1403.0	12.4	495.7	184.7	132.6
STD. DEV.	0.9	178.8	1.2	76.0	27.4	68.9

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Site 01 - Test 10

TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	SO2 (PPMV)	NOX (PPMV)	THC (PPMV)
1335	3.1				4.1	24.4
1340	13.0	921.7	12.4	359.6	221.3	25.6
1345	12.9	1021.4	12.5	354.3	225.2	25.8
1350	13.0	969.1	13.5	370.4	263.5	23.6
1355	13.2	860.5	12.3	347.5	225.0	24.2
1400	13.2	913.0	12.4	340.1	229.3	29.9
1405	13.4	924.1	12.2	330.7	222.7	25.2
1410	13.2	921.2	12.1	343.0	228.8	26.7
1415	13.3	940.3	11.9	336.5	229.9	26.2
1420	13.0	971.9	13.1	372.0	256.2	23.6
1425	12.9	978.4	12.6	368.3	239.6	23.5
1430	12.8	904.7	12.8	372.4	237.9	25.9
1435	13.1	874.8	12.4	367.0	232.6	33.9
1440	12.7	873.8	12.8	411.8	233.5	25.9
1445	12.8	842.7	13.0	408.2	233.1	28.6
1450	12.4	826.0	13.5	436.6	228.2	25.7
1455	12.5	890.8	12.9	413.9	229.5	26.4
1500	12.5	831.6	13.0	409.9	222.8	24.1
1505	12.7	834.2	12.9	397.4	224.2	21.8
1510	12.5	790.2	13.4	433.7	224.6	26.4
1515	12.4	823.1	13.7	450.8	237.3	24.6
1520	12.4	819.4	14.1	490.1	241.0	25.3
1525	11.9	747.6	13.8	482.1	227.9	28.5
1530	11.6	775.3	14.0	499.9	228.7	32.2
1535	12.6	755.9	13.1	497.3	229.6	38.1
1540	12.3	756.7	13.5	523.5	228.8	26.5
1545	12.2	779.5	13.4	520.2	230.6	25.8
1550	12.1	848.4	14.1	581.4	244.7	26.5
1555	12.2	761.7	13.3	515.7	235.1	27.1
1600	12.2	833.7	13.8	545.6	237.1	26.7
1605	12.5	785.8	13.4	513.5	243.0	24.8
1610	11.9	743.5	13.6	522.5	234.3	24.4
1615	12.2	758.9	13.2	494.1	238.6	24.2
1620	12.2	744.7	13.5	499.6	238.1	23.4
1625	12.8	747.2	12.0	409.3	233.8	22.6
1630	12.9	803.7	11.9	406.6	229.2	22.8
1635	13.4	884.7	10.9	342.9	233.0	22.9
1640	13.6	925.3	10.7	309.3	235.7	23.7
1645	13.5	898.3	11.1	329.5	239.8	22.3
1650	13.8	891.2	10.5	297.1	237.4	21.4
1655	13.8	840.9	10.8	308.6	239.6	29.5
1700	13.6	832.8	11.0	329.0	240.7	32.8
1705	13.3	862.4	12.2	389.2	251.4	32.1
1710	11.7	937.1	14.0	513.9	261.4	36.5
1715	10.2	1367.1	15.9	640.1	74.3	47.8
1720	9.5	1803.0	17.4	704.3	95.9	57.0
1725	9.3	2146.5	17.8	771.1	114.0	80.0
1730	8.3	2228.1	18.8	772.2	140.1	157.8
1735	8.2	2247.5	19.2	752.6	155.6	196.8
1740	8.2	2226.9	19.5	797.6	153.3	259.6
1745	8.9	2234.1	17.5	767.5	129.9	149.9
1750	9.4	1979.6	17.4	716.7	108.0	125.6
1755	9.9	1432.7	16.3	674.3	84.4	63.5
1800	10.1	1203.0	16.0	643.6	75.3	61.7
1805	10.9	1098.9	15.2	614.6	68.2	41.9
1810	10.7	1090.4	14.9	590.1	65.1	48.4
1815	11.4	975.1	13.7	528.8	56.6	39.5
1820	11.5	977.9	14.1	553.3	275.9	39.3
NO. PTS.	58	57	57	57	58	58
MEAN	11.9	1046.6	13.7	482.0	201.8	43.6
STD. DEV.	1.9	427.9	2.1	137.8	64.4	44.9

CEM Test Results

CEMS DATA - SITE 01 - TEST 11

TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	SO2 (PPMV)	NOX (PPMV)	THC (PPMV)
1030	12.2	966.2	12.8	371.4		97.8
1035	12.1	1270.8	13.0	391.9		70.3
1040	12.3	1186.7	13.0	394.9		68.9
1045	12.4	1290.3	12.6	355.3		69.9
1050	12.8	1309.1	12.8	356.9		80.1
1055	12.8	1291.4	12.7	359.0		51.0
1100	12.8	1303.1	12.9	367.7		51.4
1105	14.0	1374.7	12.9	340.5		48.9
1110	12.2	1307.9	13.8	390.6		50.2
1115	11.8	1227.7	14.4	428.6		45.9
1120	17.7	1302.6	13.7	412.1		38.4
1125	11.9	1270.0	14.4	450.3		73.4
1130	12.1	1216.0	13.9	444.4		41.5
1135	12.2	1230.8	13.9	435.2		33.6
1140	11.8	1244.8	14.5	476.4		39.3
1145	11.9	1217.7	14.0	463.7		56.1
1150	18.3	1360.6	14.3	477.3		49.1
1155	11.3	1270.5	15.7	530.8		63.2
1200	10.8	1238.6	16.3	554.9		53.8
1205	19.5	1025.6	16.1	559.0	253.1	48.2
1210	10.5	1355.8	16.7	578.9	277.3	47.8
1215	10.0	1249.2	16.8	629.1	258.1	42.3
1220	16.3	1376.0	17.2	611.3	290.8	41.1
1225	9.7	1309.4	18.3	687.3	282.3	39.3
1230	8.9	1284.8	18.8	729.8	277.4	36.2
1235	9.3	1267.6	17.7	689.5	282.7	29.4
1240	10.3	1240.8	17.6	697.0	270.0	26.5
1245	10.1	1204.1	17.9	702.6	261.7	23.6
1250	11.9	1218.5	18.2	717.4	269.6	20.7
1255	8.4	1336.0	19.8	810.4	290.8	8.7
1300	7.7	1525.9		870.9	309.4	6.9
1305	14.5	927.0		799.6	286.8	10.6
1310	9.1	1326.9	19.2	744.0	286.3	2.1
1315	9.2	1365.4	19.1	766.9	287.4	3.9
1320	9.1	1414.1		858.1	302.7	3.8
1325	8.5	1349.5		793.9	306.0	
1330	8.8	1270.8	19.5	742.8	296.7	
1335	9.2	1278.1	18.6	729.7	286.2	
1340	8.2	1328.4		800.6	298.1	
1345	8.5	1231.5	19.9	787.5	288.6	55.4
1350	10.5	1198.1	18.7	770.7	284.7	49.3
1355	9.3	956.8	18.6	741.0	268.3	45.0
1400	9.6	1043.0	18.2	744.7	261.1	33.5
1405	14.8	587.3	17.8	736.4	244.2	38.4
1410	10.4	920.9	17.4	719.5	258.6	29.3
1415	10.5	953.4	17.1	717.7	267.6	33.0
1420	10.6	903.3	17.2	698.7	266.4	33.5
1425	10.5	927.3	16.8	725.0	265.2	34.5
1430	10.9	919.2	16.7	695.9	268.4	28.4
1435	11.7	944.6	15.4	636.0	265.8	33.8
1440	11.5	905.9	15.2	641.7	258.7	32.0
1445	12.5	945.3	14.2	600.6	278.5	34.4
1450	12.8	958.5	14.5	598.7	281.4	37.2
1455	12.9	820.1	13.6	559.1	262.8	26.7
1500	13.6	861.0	12.7	504.2	276.9	34.2
1505	16.7	735.2	11.8	440.8	287.1	40.6
1510	12.8	906.2	14.2	527.4	267.6	37.1
1515	12.1	797.8	14.6	501.6	237.7	38.6
1520	11.8	896.7	15.8	575.6	246.4	42.6
1525	11.4	857.3	15.4	570.7	245.6	45.6
1530	10.9	961.3	15.7	536.1	267.1	49.0
1535	11.8	928.0	15.1	561.5	261.5	50.9
1540	11.7	946.3	14.9	593.1	272.0	25.1
1545	11.6	996.1	15.3	225.5	296.2	27.4
1550	12.3	1006.9	15.1	578.9	288.6	46.1
1555	11.3	1017.4	15.8	623.0	288.9	53.7
1600	11.2	1048.2	16.1	628.8	296.5	48.9
1605	16.0	577.4	15.9	596.1	294.5	49.5
1610	10.3	1063.7	17.4	714.7	297.2	36.1
1615	10.5	1045.3	17.3	686.8	294.4	50.1
NO. PTS.	70	70	65	70	51	66
MEAN	11.7	1119.9	15.8	596.6	276.7	40.8
STD. DEV.	2.3	207.2	2.1	148.4	16.9	17.7

APPENDIX A.3

AMBIENT AIR - XAD TRAIN FIELD RESULTS

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```
      R A D I A N   S O U R C E   T E S T
      E P A   M E T H O D   2 - 5
      ( R A W   D A T A )
   PLANT                : SITE 01
   PLANT SITE           :
   SAMPLING LOCATION    : COMBUSTION AIR INTAKE
   TEST #               : AMB-XAD-A
   DATE                 : 10/8-9-10/84
   TEST PERIOD          : (1535-1935 1340-1745 1030-1410)

PARAMETER                              VALUE
---------                              -----

Sampling time (min.)                    705
Barometric Pressure (in.Hg)             30.4
Sampling nozzle diameter (in.)          0
Meter Volume (cu.ft.)                   381.289
Meter Pressure (in.H2O)                 .75
Meter Temperature (F)                   98
Stack dimension (sq.in.)                0
Stack Static Pressure (in.H2O)          .001
Stack Moisture Collected (gm)           98.5
Absolute stack pressure(in Hg)          30.40008
Average stack temperature (F)           0
Percent CO2                             .001
Percent O2                              20.9
Percent N2                              79.1
Delps Subroutine result                 0
DGM Factor                              .9956
```

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```
   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D S   2 - 5
   F I N A L   R E S U L T S
PLANT               : SITE 01
PLANT SITE          :
SAMPLING LOCATION   : COMBUSTION AIR INTAKE
TEST #              : AMB-XAD-A
DATE                : 10/8-9-10/84
TEST PERIOD         : (1535-1935 1340-1745 1030-1410)

   PARAMETER              RESULT
   ---------              ------

   Vm(dscf)                365.6268
   Vm(dscm)                10.35455
   Vw gas(scf)             4.644275
   Vw gas (scm)            .1315259
   % moisture              1.254291
   Md                      .9874571
   MWd                     28.83644
   MW                      28.70052





                                     Program Revision:1/16/84
```

```
     R A D I A N   S O U R C E   T E S T
     E P A   M E T H O D   2 - 5
     ( R A W   D A T A )
   PLANT                  : SITE 01
   PLANT SITE             :
   SAMPLING LOCATION      : COMBUSTION AIR INTAKE
   TEST #                 : AMB-XAD-RUN B
   DATE                   : 10/8-9-10/84
   TEST PERIOD            : (1535-1935 1340-1745  1030-1410)

PARAMETER                                VALUE
---------                                -----

Sampling time (min.)                      705
Barometric Pressure (in.Hg)               30.4
Sampling nozzle diameter (in.)            0
Meter Volume (cu.ft.)                     402.855
Meter Pressure (in.H2O)                   .75
Meter Temperature (F)                     100.9
Stack dimension (sq.in.)                  0
Stack Static Pressure (in.H2O)            .001
Stack Moisture Collected (gm)             100.9
Absolute stack pressure(in Hg)            30.40008
Average stack temperature (F)             0
Percent CO2                               .001
Percent O2                                20.9
Percent N2                                79.1
Delps Subroutine result                   0
DGM Factor                                1.005
                                          0
   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D S   2 - 5
   F I N A L   R E S U L T S
PLANT                  : SITE 01
PLANT SITE             :
SAMPLING LOCATION      : COMBUSTION AIR INTAKE
TEST #                 : AMB-XAD-RUN B
DATE                   : 10/8-9-10/84
TEST PERIOD            : (1535-1935 1340-1745  1030-1410)

   PARAMETER                      RESULT
   ---------                      ------

   Vm(dscf)                        387.9381
   Vm(dscm)                        10.98641
   Vw gas(scf)                     4.757436
   Vw gas (scm)                    .1347306
   % moisture                      1.211482
   Md                              .9878852
   MWd                             28.83644
   MW                              28.70516




                                          Program Revision:1/16/84
```

APPENDIX A.4

EPA METHOD 3
FIXED GAS FIELD RESULTS

Run #	Compound	Trial 1	Trial 2	Average
01-B9-IB	O_2	- Leaky Bag Used CEM Data		
	CO_2			
	N_2			
01-B10-IB	O_2	-	15.30	15.3
	CO_2	5.11	4.89	5.0
	N_2	-	81.42	79.7
01-B11-IB	O_2	13.94	14.13	14.0
	CO_2	5.56	5.31	5.4
	N_2	74.87	74.40	80.5
01-A9-IB	O_2	18.72	18.77	18.7
	CO_2	2.36	2.26	2.3
	N_2	78.34	78.95	78.6
01-A10-IB	O_2	18.83	18.95	18.9
	CO_2	2.37	2.16	2.3
	N_2	82.35	76.63	78.8
01-A11-IB	O_2	16.75	16.75	16.7
	CO_2	3.01	2.99	3.0
	N_2	78.27	77.85	78.1

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APPENDIX A.5

MODIFIED METHOD 5
and
EPA METHODS 1-4 FIELD SAMPLE CALCULATIONS

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RADIAN SOURCE TEST
EPA METHODS 2-5
DEFINITION OF TERMS

PARAMETER	DEFINITION
Tt(min.)	TOTAL SAMPLING TIME
Dn(in.)	SAMPLING NOZZLE DIAMETER
Ps(in.H2O)	ABSOLUTE STACK STATIC GAS PRESSURE
Vm(cu.ft.)	ABSOLUTE VOLUME OF GAS SAMPLE MEASURED BY DGM
Vw(gm.)	TOTAL STACK MOISTURE COLLECTED
Pm(in.H2O)	AVERAGE STATIC PRESSURE OF DGM
Tm(F)	AVERAGE TEMPERATURE OF DGM
Pb(in.Hg.)	BAROMETRIC PRESSURE
% CO2	CARBON DIOXIDE CONTENT OF STACK GAS
% O2	OXYGEN CONTENT OF STACK GAS
% N2	NITROGEN CONTENT OF STACK GAS
SQR(DELPS)	AVE. SQ. ROOT OF S-PITOT DIFF. PRESSURE-TEMP. PRODUCTS
As(sq.in.)	CROSS-SECTIONAL AREA OF STACK(DUCT)
Ts(F)	TEMPERATURE OF STACK
Vm(dscf)	STANDARD VOLUME OF GAS SAMPLED ,Vm(std),AS DRY STD. CF
Vm(dscm)	STANDARD VOLUME OF GAS SAMPLED,Vm(std),AS DRY STD. CM
Vw gas(scf)	VOLUME OF WATER VAPOR IN GAS SAMPLE,STD
% moisture	WATER VAPOR COMPOSITION OF STACK GAS
Md	PROPORTION, BY VOLUME,OF DRY GAS IN GAS SAMPLE
MWd	MOLECULAR WEIGHT OF STACK GAS,DRY BASIS LB/LB-MOLE
MW	MOLECULAR WEIGHT OF STACK GAS,WET BASIC LB/LB-MOLE
Vs(fpm)	AVERAGE STACK GAS VELOCITY
Flow(acfm)	AVERAGE STACK GAS FLOW RATE(ACTUAL STACK COND.)
Flow(acmm)	AVERAGE STACK GAS FLOW RATE(ACTUAL STACK COND.)
Flow(dscfm)	AVERAGE STACK GAS VOLUMETRIC FLOW RATE(DRY BASIS)
Flow(dscmm)	AVERAGE STACK GAS VOLUMETRIC FLOW RATE(DRY BASIS)
% I	PERCENT ISOKINETIC
% EA	PERCENT EXCESS AIR IN STACK GAS
DGM	DRY GAS METER
Y	DRY GAS METER CORRECTION FACTOR
Pg	STACK STATIC GAS PRESSURE
Cp	PITOT COEFFICIENT
dH	ORIFICE PLATE DIFF. PRESS. VALUE
dP	PITOT DIFF. PRESS. VALUE
*** EPA STANDARD CONDITIONS	Temperature = 68 deg-F (528 deg-R) Pressure = 29.92 in. Hg.

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RADIAN SOURCE TEST
EPA METHOD 2-5
SAMPLE CALCULATION

PLANT : SITE 01
PLANT SITE :
SAMPLING LOCATION : SCRUBBER EXHAUST "A"
TEST # : HR-A-9
DATE : 10/08/84
TEST PERIOD : 1500-1920

1) Volume of dry gas sampled at standard conditions (68 deg-F ,29.92 in. Hg).

$$Vm(std) = \frac{Y \times Vm \times [T(std) + 460] \times [Pb + (Pm/13.6)]}{P(std) \times (Tm + 460)}$$

$$Vm(std) = \frac{.9959 \times 215.641 \times 528 \times [30.4 + (2.89/13.6)]}{29.92 \times (95.8 + 460)}$$

$$Vm(std) = 208.737 \text{dscf}$$

2) Volume of water vapor at standard conditions:

$$Vw(gas) = 0.04715 \text{ cf/gm} \times W(1) \text{ gm}$$

$$Vw(gas) = 0.04715 \times 98.85 = 4.661 \text{ scf}$$

3) Percent Moisture in stack gas :

$$\%M = \frac{100 \times Vw(gas)}{Vm(std) + Vw(gas)}$$

$$\%M = \frac{100 \times 4.661}{208.737 + 4.661} = 2.18 \%$$

4) Mole fraction of dry stack gas :

$$Md = \frac{100 - \%M}{100} = \frac{100 - 2.18}{100} = .9781592$$

SAMPLE CALCULATION
PAGE TWO

```
)Average Molecular Weight of DRY stack gas :

        MWd = (.44 x %CO2) + (.32 x %O2) + (.28 x %N2)

        MWd = (.44 x 2.31 ) + (.32 x 18.74 ) + (.28 x  78.95 ) =  29.1192

)Average Molecular Weight of wet stack gas :

        MW   = MWd x Md + 18(1 - Md)

        MW   = 29.1192  x  .9781592  + 18(1 -  .9781592 )  =  28.87635

) Stack gas velocity in feet-per-minute (fpm) at stack conditions :

s = KpxCp x [SQRT (dP)](ave} x SQRT [Ts {avg}] x SQRT [1/(PsxMW)] x 60sec/min

    Vs = 85.49 x .84 x 60 x  5.751807 x SQRT[1/( 30.40221  X  28.87635 )]

    Vs =  836.4242  FPM

) Average stack gas dry volumetric flow rate (DSCFM) :

              Vs x As x Md x T(std) x Ps
    Qsd =  ----------------------------------------
           144 cu.in./cu.ft. x (Ts +460) x P(std)

            836.4242 x 1734.949 x .9781592 x528x 30.40221
    Qsd =  ----------------------------------------
            144 x  621  x 29.92

    Qsd =  8516.207 dscfm
```

SAMPLE CALCULATION
PAGE THREE

```
9)Isokinetic sampling rate (%) :

        Dimensional Constant C = K4 x 60 x 144 x [1 / (Pi  /4)]
        K4 = .0945 FOR ENGLISH UNITS

                 C x Vm(std) x (Ts + 460)
        I% =    --------------------------------
                Vs x Tt x Ps x Md x (Dn)^2

                 1039.574 x 208.7371 x 621
        I% = -----------------------------------
             836.4242 x 240 x 30.40221 x .9781592 x( .486 )^2

        I% =  95.57008

10) Excess air (%) :

                100 x %02              100 x 18.74
        EA =    ------------- = -------------
                (.264 x %N2) - %02  (.264 x 78.95 ) - 18.74

        EA =       891.19

11) Particulate Concentration :

        Cs = ( grams part.) / Vm(std) =  0 / 208.7371

        Cs =       0.0000000 Grams/DSCF

                T(std) x Md x Ps x Cs
        Ca =    ---------------------------
                P(std) x Ts

                528 x .9781592  x 30.40221  x      0.0000000
        Ca =    ---------------------------
                29.92       x      621

        Ca =            0.0000000 Grams/ACF

        LBS/HR =  Cs x 0.002205 x Qsd x 60

        LBS/HR =        0.0000000x 0.002205 x  8516.2 x 60

        LBS/HR = 0

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```

```
          R A D I A N   S O U R C E   T E S T
          E P A   M E T H O D   2 - 5
          S A M P L E   C A L C U L A T I O N
        PLANT                : SITE 01
        PLANT SITE           :
        SAMPLING LOCATION    : SCRUBBER INLET "B"
        TEST #               : HR-B-9
        DATE                 : 10/08/84
        TEST PERIOD          : 1500-1934

1) Volume of dry gas sampled at standard conditions (68 deg-F ,29.92 in. Hg).

              Y x Vm x [T(std) + 460] x [Pb +(Pm/13.6)]
   Vm(std) = -----------------------------------------
                  P(std) x (Tm + 460)

             .9959 x 158.583  x 528 x [ 30.4  + ( 1.26 /13.6)]
   Vm(std) = ---------------------------------------------
                29.92    x ( 107.4  + 460)

   Vm(std) =  149.779dscf

2) Volume of water vapor at standard conditions:

   Vw(gas) =  0.04715 cf/gm x W(l) gm

   Vw(gas) =  0.04715 x  944.8    =  44.547 scf

3) Percent Moisture in stack gas :

           100 x Vw(gas)
   %M = --------------------
        Vm(std)   + Vw(gas)

            100 x  44.547
   %M = -------------------- =  22.92 %
         149.779 +   44.547

4) Mole fraction of dry stack gas :

            100 -    %M              100 -  22.92
   Md  =    ------------          = ------------ =  .7707601
               100                      100
```

SAMPLE CALCULATION
PAGE TWO

5)Average Molecular Weight of DRY stack gas :

MWd = (.44 x %CO2) + (.32 x %O2) + (.28 x %N2)

MWd = (.44 x 7.4) + (.32 x 12.2) + (.28 x 80.6) = 29.728

6)Average Molecular Weight of wet stack gas :

MW = MWd x Md + 18(1 - Md)

MW = 29.728 x .7707601 + 18(1 - .7707601) = 27.03948

7) Stack gas velocity in feet-per-minute (fpm) at stack conditions :

Vs = KpxCp x [SQRT (dP)]{ave} x SQRT [Ts {avg}] x SQRT [1/(PsxMW)] x 60sec/mi

Vs = 85.49 x .84 x 60 x 8.632847 x SQRT[1/(30.39265 X 27.03948)]

Vs = 1297.527 FPM

8) Average stack gas dry volumetric flow rate (DSCFM) :

```
          Vs x As x Md x T(std) x Ps
Qsd =  ----------------------------------------
       144 cu.in./cu.ft. x (Ts +460) x P(std)

         1297.527 x 1188 x .7707601 x528x 30.39265
Qsd =  ----------------------------------------
        144 x  1206.333  x 29.92

Qsd =  3668.286 dscfm
```

```
                 S A M P L E   C A L C U L A T I O N
                 P A G E   T H R E E


9)Isokinetic sampling rate (%) :

        Dimensional Constant C = K4 x 60 x 144 x [1 / (Pi  /4)]
        K4 = .0945 FOR ENGLISH UNITS

                     C x Vm(std) x (Ts + 460)
        I% =      -------------------------------------
                  Vs x Tt x Ps x Md x (Dn)^2

                     1039.574 x 149.7788 x 1206.333
        I% = ----------------------------------------------
                1297.527 x 270 x 30.39265 x .7707601 x( .497 )^2

        I% =  92.66008

10) Excess air (%) :

                  100 x %02              100 x 12.2
        EA =      --------------- = ---------------
                  (.264 x %N2) - %02  (.264 x 80.6 ) - 12.2

        EA =        134.38

11) Particulate Concentration :

        Cs = ( grams part.) / Vm(std) =  0 / 149.7788

        Cs =        0.0000000 Grams/DSCF

                  T(std) x Md x Ps x Cs
        Ca =      ------------------------------
                  P(std) x Ts

                  528 x .7707601  x 30.39265  x      0.0000000
        Ca =      ------------------------------
                  29.92        x     1206.333

        Ca =             0.0000000 Grams/ACF

        LBS/HR =  Cs x 0.002205 x Qsd x 60

        LBS/HR =         0.0000000x 0.002205 x  3668.3 x 60

        LBS/HR = 0

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```

APPENDIX B
PROCESS MONITORING DATA

TABLE B-1. INCINERATOR FEED RATE, SCRUBBER PRESSURE DROP, AND AUXILIARY FUEL USAGE DATA

Run No./ Time	Sludge Feed Rate (Wet, lb/hr)[a]	Venturi Scrubber ΔP (in. H_2O)[b]	Impingement Tray Scrubber ΔP (in. H_2O)[b]	Auxiliary Fuel	
				Oil Gal/Hr[c]	Gas Cuft/hr[d]
Run 09					
1500	4,100	19.3	5.5		
1600	4,100	19.0	5.5		
1700	4,100	19.0	5.5		
1800	4,100	19.0	5.5		
1900	4,100	19.0	5.5		
2000	3,800	19.0	5.5		
Avg	4,050	19.0	5.5	9.3	2.4
Run 10					
1400	3,500	16.5	5.5		
1500	4,300	16.5	5.5		
1600	5,000	17.0	5.5		
1700	4,900	17.0	5.5		
1800	4,100	18.5	5.5		
Avg	4,360	17.1	5.5	21.3	3.4
Run 11					
1000	4,600	19.5	5.0		
1100	3,900	20.0	5.0		
1200	3,800	19.5	4.5		
1300	4,000	19.0	5.0		
1400	4,500	19.0	5.0		
1500	3,800	19.5	5.0		
1600	3,700	18.5	4.5		
Avg	4,043	19.3	4.8	9.1	1.8

[a] To convert from lb/hr to kg/hr, multiply value in lb/hr by 0.454.

[b] To convert from inH_2O to kPa, multiply value in inH_2O by 0.249.

[c] To convert from gal/hr to cu meter/hr, multiply value in gal/hr by 0.00379.

[d] To convert from cu ft/hr to cu meter/hr, multiply value in cu ft/hr by 0.0283.

NOTE: Time = 1300 corresponds to data from 1200 to 1300.

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TABLE B-2. SLUDGE FEED CHARACTERISTICS

Run No.	Sludge % Solids (Wt. %)	Sludge % Volatiles (Wt. %)
9	19.08	68
10	21.84	68
11	22.35	72

TABLE B-3. HOURLY AVERAGE HEARTH TEMPERATURES DURING DIOXIN TESTS[a]

Time	#1 (°F)	#2 (°F)	#3 (°F)	#4 (°F)	#5 (°F)	#6 (°F)
10/8						
1500	691	1146	1372	1002	364	113
1600	695	1137	1364	997	363	111
1700	716	1210	1386	995	363	115
1800	728	1225	1445	970	355	117
1900	709	1160	1395	958	345	114
2000	745	1225	1472	954	364	121
Avg Run #9	714	1184	1406	979	359	115
1300	805	1149	1373	1416	589	107
1400	790	1173	1403	1439	604	110
1500	762	1179	1440	1461	625	113
1600	780	1157	1531	1426	642	119
1700	741	1080	1508	1394	650	125
1800	789	1181	1563	1400	651	132
Avg Run #10	778	1153	1470	1423	627	118
1000	735	1000	1288	1287	525	128
1100	743	1005	1388	1280	522	134
1200	764	1060	1414	1205	497	137
1300	834	1245	1488	1110	492	149
1400	860	1272	1514	1045	462	162
1500	802	1206	1498	750	461	161
1600	793	1198	1467	728	405	163
Avg Run #11	790	1141	1437	1058	480	148

[a] Data shown in units used by host plant. To convert from °F to °C, use the formula: °C = (°F - 32)/1.8.

APPENDIX C
SAMPLE SHIPMENT LETTERS

October 17, 1984

U.S. EPA ECC Toxicant Analysis Center
Building 1105
Bay St. Louis, MO 39529

Attention: Danny McDaniel

Subject: Tier 4-Analysis Instructions

Dear Sir:

The objective of this letter is to clarify extraction and analysis instructions and priorities for individual samples from specific Tier 4 combustion sites. This instruction letter is #1 and pertains to EPA Site # 01 The Episode # is 2086. The shipment consists of 3 boxes containing a total of 61 samples.

1. The following samples require immediate extraction and analysis. (Priority #1 Samples)

System blanks from Radian-RTP laboratory including the following samples:

SCC #	Fraction
DC 005223	Glassware Blank Extract
DC 005224	Filter Extract (50)
DC 008301	Methylene Chloride Extract
DC 008302	Methylene Chloride Neat
DC 005222	XAD Blank
DC 008303	Blank Filters (6)

Norfolk test samples include the following:

Radian Run # 01-1008-A9-MM5 (Total of 6 Train Components)

SCC #	Container	Fraction
DC 005201	1	Filter
DC 005201	SM	XAD Module
DC 005201	2	Probe Rinse
DC 005201	3	Coil Rinse
DC 005201	4	Condensate
DC 005201	5	Impinger Solution

Radian Run # 01-1009-A10-MM5 (Total of 6 Train Components)

DC 005203	1	Filter
DC 005203	SM	XAD Module
DC 005203	2	Probe Rinse
DC 005203	3	Back Half/Coil Rinse
DC 005203	4	Condensate
DC 005203	5	Impinger Solutions

Radian Run # 01-1010-A11-MM5 (Total of 6 Train Components)

SCC #	Container	Fraction
DC 005205	1	Filter
DC 005205	SM	XAD Module
DC 005205	2	Probe Rinse
DC 005205	3	Back Half/Coil Rinse
DC 005205	4	Condensate
DC 005205	5	Impinger Solution

Radian Run # 01-1010-B12-MM5 (Total of 6 Train Components)

DC 005207	1	Filter
DC 005207	SM	XAD Module
DC 005207	2	Probe Rinse
DC 005207	3	Back Half/Coil Rinse
DC 005207	4	Condensate
DC 005207	5	Impinger Rinse

BOTTOM ASH - PROCESS SAMPLE

DC 005209	ND	ASH
DC 005210	ND	ASH
DC 005211	ND	ASH

2. The following aqueous samples need to be extracted immediately upon receipt and held for analysis. The goal is to extract these samples within 14 days of sampling. (Priority #2 Aqueous Samples)

SCC #	Container #	Fraction
DC 005219	ND	Scrubber Blowdown
DC 005220	ND	Scrubber Blowdown
DC 005221	ND	Scrubber Blowdown

Radian Run # 01-1008-B9-MM5 (Total of 7 Train Components)

DC 005202	2	Probe Rinse
DC 005202	3	Back Half/Coil Rinse
DC 005202	4	Condensate
DC 005202	5	Impinger

Radian Run # 01-1009-B10-MM5 (Total of 7 Train Components/Bottles)

SCC #	Container #	Fraction
DC 005204	2	Probe Rinse
DC 005204	3	Back Half/Coil Rinse
DC 005204	4	Condensate
DC 005204	5	Impinger

Radian Run # 01-1010-B11-MM5 (Total of 7 Train Components)

DC 005206	2	Probe Rinse
DC 005206	3	Back Half/Coil Rinse
DC 005206	4	Condensate
DC 005206	5	Impinger

3. The following Priority #2 nonaqueous samples need to be held pending the results of the Priority #1 analysis.

SCC #	Container #	Fraction
Process Samples		
DC 005213	ND	Sludge
DC 005214	ND	Sludge
DC 005215	ND	Sludge

Radian Run # 01-1008-B9-MM5 (Nonaqueous Components)

DC 005202	1	Filter
DC 005202	SM	XAD Module

Radian Run # 01-1009-B10-MM5 (Nonaqueous Components)

DC 005204	1	Filter
DC 005204	SM	XAD Module

Radian Run # 01-1010-B11-MM5 (Nonaqueous Components)

DC 005206	1	Filter
DC 005206	SM	XAD Module

Radian Run # 01-1010-K1-AMB-XAD

DC 005212	SM	XAD Module

4. The following samples should be held for extraction and potential analysis pending the results of Priority #2 samples. (Priority #3 Samples)

SCC #	Container #	Fraction
DC 005216	ND	Fuel Oil
DC 005217	ND	Fuel Oil
DC 005218	ND	Fuel Oil

In the future, Priority #3 samples will not be shipped from the other Tier 4 tests; these will be held at Radian Corporation until notified by EPA.

If there are any questions concerning this sample shipment, please contact either Bob Jongleux or Larry Keller or Radian Corporation at (919) 541-9100.

Sincerely,
TEST TEAM LEADER

10/16/84 RFJ

APPENDIX D
DIOXIN/FURAN ANALYTICAL DATA FOR GASEOUS SAMPLES

TABLE D-1. DIOXIN/FURAN ANALYTICAL DATA FOR MM5 TRAINS SITE SSI-A, SCRUBBER OUTLET LOCATION

Isomer/ Homologue	Amount Detected, Picograms Per Sample Train		
	Run 09	Run 10	Run 11
Dioxins			
2378-TCDD	30	54	27
Other TCDD	10,044	9,581	8,271
Penta CDD	125	248	183
Hexa CDD	0	737	0
Hepta CDD	2,239	1,794	0
Octa CDD	5,330	3,258	0
Total PCDD	17,768	15,672	8,481
Furans			
2378-TCDF	NR	NR	NR
Other TCDF	29,000	26,400	30,000
Penta CDF	9,400	7,600	9,100
Hexa CDF	0	0	438
Hepta CDF	367	463	492
Octa CDF	0	216	0
Total PCDF	38,767	34,679	40,030

NR = not reported by Troika.

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APPENDIX E
RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA

APPENDIX E.1

RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA
SCRUBBER OUTLET EXHAUST STACK
(As-measured Concentrations)

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TABLE E-1. DIOXIN/FURAN EMISSIONS DATA FOR RUN 09 SITE SSI-A (SCRUBBER OUTLET LOCATION)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	5.08E-03(2.03E-03)	3.79E-04(1.52E-04)	7.35E-02
Other TCDD	1.70E+00(N/A)	1.27E-01(N/A)	2.46E+01
Penta-CDD	2.12E-02(N/A)	1.43E-03(N/A)	3.06E-01
Hexa-CDD	ND (4.06E-02)	ND (2.50E-03)	ND (5.88E-01)
Hepta-CDD	3.79E-01(N/A)	2.14E-02(N/A)	5.48E+00
Octa-CDD	9.02E-01(N/A)	4.72E-02(N/A)	1.31E+01
Total PCDD	3.01E+00	1.97E-01	4.35E+01
FURANS			
2378 TCDF	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDF	4.91E+00(N/A)	3.86E-01(N/A)	7.10E+01
Penta-CDF	1.59E+00(N/A)	1.13E-01(N/A)	2.30E+01
Hexa-CDF	ND (9.44E-02)	ND (6.06E-03)	ND (1.37E+00)
Hepta-CDF	6.21E-02(N/A)	3.65E-03(N/A)	8.99E-01
Octa-CDF	ND (5.65E-02)	ND (3.06E-03)	ND (8.18E-01)
Total PCDF	6.56E+00	5.02E-01	9.49E+01

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
6000 operating hours per year

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TABLE E-2. DIOXIN/FURAN EMISSIONS DATA FOR RUN 10
SITE SSI-A (SCRUBBER OUTLET LOCATION)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	9.12E-03(1.69E-03)	6.81E-04(1.26E-04)	1.33E-01
Other TCDD	1.62E+00(N/A)	1.21E-01(N/A)	2.37E+01
Penta-CDD	4.19E-02(N/A)	2.83E-03(N/A)	6.12E-01
Hexa-CDD	1.24E-01(N/A)	7.66E-03(N/A)	1.82E+00
Hepta-CDD	3.03E-01(N/A)	1.72E-02(N/A)	4.43E+00
Octa-CDD	5.50E-01(N/A)	2.88E-02(N/A)	8.04E+00
Total PCDD	2.65E+00	1.78E-01	3.87E+01
FURANS			
2378 TCDF	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDF	4.46E+00(N/A)	3.51E-01(N/A)	6.52E+01
Penta-CDF	1.28E+00(N/A)	9.08E-02(N/A)	1.88E+01
Hexa-CDF	ND (7.30E-02)	ND (4.68E-03)	ND (1.07E+00)
Hepta-CDF	7.82E-02(N/A)	4.60E-03(N/A)	1.14E+00
Octa-CDF	3.65E-02(2.42E-02)	1.98E-03(1.31E-03)	5.33E-01
Total PCDF	5.86E+00	4.48E-01	8.56E+01

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
6000 operating hours per year

TABLE E-3. DIOXIN/FURAN EMISSIONS DATA FOR RUN 11
SITE SSI-A (SCRUBBER OUTLET LOCATION)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	4.49E-03(1.50E-03)	3.36E-04(1.12E-04)	6.11E-02
Other TCDD	1.38E+00(N/A)	1.03E-01(N/A)	1.87E+01
Penta-CDD	ND (3.04E-02)	ND (2.06E-03)	ND (4.14E-01)
Hexa-CDD	1.10E-01(N/A)	6.75E-03(N/A)	1.49E+00
Hepta-CDD	4.13E-01(N/A)	2.34E-02(N/A)	5.62E+00
Octa-CDD	9.78E-01(N/A)	5.11E-02(N/A)	1.33E+01
Total PCDD	2.88E+00	1.84E-01	3.92E+01
FURANS			
2378 TCDF	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDF	4.99E+00(N/A)	3.92E-01(N/A)	6.79E+01
Penta-CDF	1.51E+00(N/A)	1.07E-01(N/A)	2.06E+01
Hexa-CDF	7.29E-02(N/A)	4.68E-03(N/A)	9.91E-01
Hepta-CDF	8.19E-02(N/A)	4.81E-03(N/A)	1.11E+00
Octa-CDF	ND (4.11E-02)	ND (2.23E-03)	ND (5.59E-01)
Total PCDF	6.66E+00	5.09E-01	9.06E+01

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
6000 operating hours per year

APPENDIX E.2

RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA
SCRUBBER OUTLET EXHAUST STACK
(Corrected to 3% Oxygen)

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TABLE E-4. DIOXIN/FURAN EMISSIONS DATA FOR RUN 09
SITE SSI-A (SCRUBBER OUTLET LOCATION)
(Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	4.04E-02(1.62E-02)	3.02E-03(1.21E-03)	7.35E-02
Other TCDD	1.35E+01(N/A)	1.01E+00(N/A)	2.46E+01
Penta-CDD	1.68E-01(N/A)	1.14E-02(N/A)	3.06E-01
Hexa-CDD	ND (3.23E-01)	ND (1.99E-02)	ND (5.88E-01)
Hepta-CDD	3.02E+00(N/A)	1.71E-01(N/A)	5.48E+00
Octa-CDD	7.18E+00(N/A)	3.76E-01(N/A)	1.31E+01
Total PCDD	2.39E+01	1.57E+00	4.35E+01
FURANS			
2378 TCDF	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDF	3.91E+01(N/A)	3.07E+00(N/A)	7.10E+01
Penta-CDF	1.27E+01(N/A)	8.96E-01(N/A)	2.30E+01
Hexa-CDF	ND (7.52E-01)	ND (4.82E-02)	ND (1.37E+00)
Hepta-CDF	4.95E-01(N/A)	2.91E-02(N/A)	8.99E-01
Octa-CDF	ND (4.50E-01)	ND (2.44E-02)	ND (8.18E-01)
Total PCDF	5.22E+01	4.00E+00	9.49E+01

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
6000 operating hours per year

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TABLE E-5. DIOXIN/FURAN EMISSIONS DATA FOR RUN 10
SITE SSI-A (SCRUBBER OUTLET LOCATION)
(Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	7.78E-02(1.44E-02)	5.81E-03(1.08E-03)	1.33E-01
Other TCDD	1.38E+01(N/A)	1.03E+00(N/A)	2.37E+01
Penta-CDD	3.57E-01(N/A)	2.41E-02(N/A)	6.12E-01
Hexa-CDD	1.06E+00(N/A)	6.53E-02(N/A)	1.82E+00
Hepta-CDD	2.59E+00(N/A)	1.46E-01(N/A)	4.43E+00
Octa-CDD	4.69E+00(N/A)	2.46E-01(N/A)	8.04E+00
Total PCDD	2.26E+01	1.52E+00	3.87E+01
FURANS			
2378 TCDF	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDF	3.80E+01(N/A)	2.99E+00(N/A)	6.52E+01
Penta-CDF	1.10E+01(N/A)	7.75E-01(N/A)	1.88E+01
Hexa-CDF	ND (6.23E-01)	ND (3.99E-02)	ND (1.07E+00)
Hepta-CDF	6.67E-01(N/A)	3.92E-02(N/A)	1.14E+00
Octa-CDF	3.11E-01(2.06E-01)	1.69E-02(1.12E-02)	5.33E-01
Total PCDF	5.00E+01	3.82E+00	8.56E+01

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
6000 operating hours per year

TABLE E-6. DIOXIN/FURAN EMISSIONS DATA FOR RUN 11
SITE SSI-A (SCRUBBER OUTLET LOCATION)
(Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	1.90E-02(6.34E-03)	1.42E-03(4.74E-04)	6.11E-02
Other TCDD	5.83E+00(N/A)	4.35E-01(N/A)	1.87E+01
Penta-CDD	ND (1.29E-01)	ND (8.71E-03)	ND (4.14E-01)
Hexa-CDD	4.64E-01(N/A)	2.86E-02(N/A)	1.49E+00
Hepta-CDD	1.75E+00(N/A)	9.90E-02(N/A)	5.62E+00
Octa-CDD	4.14E+00(N/A)	2.17E-01(N/A)	1.33E+01
Total PCDD	1.22E+01	7.81E-01	3.92E+01
FURANS			
2378 TCDF	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDF	2.11E+01(N/A)	1.66E+00(N/A)	6.79E+01
Penta-CDF	6.41E+00(N/A)	4.54E-01(N/A)	2.06E+01
Hexa-CDF	3.09E-01(N/A)	1.98E-02(N/A)	9.91E-01
Hepta-CDF	3.47E-01(N/A)	2.04E-02(N/A)	1.11E+00
Octa-CDF	ND (1.74E-01)	ND (9.43E-03)	ND (5.59E-01)
Total PCDF	2.82E+01	2.16E+00	9.06E+01

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
N/A = Not applicable. QA samples indicate the method capabilities and minimum limits of detection when values are positive.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
6000 operating hours per year

APPENDIX F

RUN-SPECIFIC RISK MODELING INPUT DATA
SCRUBBER OUTLET EXHAUST STACK

TABLE F-1. RISK MODELING PARAMETERS FOR RUN 9, SITE SSI-A (SCRUBBER OUTLET LOCATION)

Stack Height (From Grade Level) = 22 m
Stack Diameter (ID) = 1.2 m
Flue Gas Flow Rate (Dry Standard) = 241 dscmm
Flue Gas Exit Temperature = 345 K
Flue Gas Exit Velocity (Actual) = 255 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	5.08E-03	7.35E-02	1.000	4.41E-01
Other TCDD	1.70E+00	2.46E+01	.010	1.48E+00
2378 TCDF	ND (N/A)	ND (N/A)	.100	ND (N/A)
Other TCDF	4.91E+00	7.10E+01	.001	4.26E-01
Penta-CDD	2.12E-02	3.06E-01	.500	9.18E-01
Penta-CDF	1.59E+00	2.30E+01	.100	1.38E+01
Hexa-CDD	ND (4.06E-02)	ND (5.88E-01)	.040	ND (1.41E-01)
Hexa-CDF	ND (9.44E-02)	ND (1.37E+00)	.010	ND (8.20E-02)
Hepta-CDD	3.79E-01	5.48E+00	.001	3.29E-02
Hepta-CDF	6.21E-02	8.99E-01	.001	5.39E-03
Octa-CDD	9.02E-01	1.31E+01	.000	.00E+00
Octa-CDF	ND (5.65E-02)	ND (8.18E-01)	.000	ND (.00E+00)
Net 2378 TCDD Equivalent Atmospheric Loading				1.71E+01

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
6000 operating hours per year

TABLE F-2. RISK MODELING PARAMETERS FOR RUN 10, SITE SSI-A (SCRUBBER OUTLET LOCATION)

Stack Height (From Grade Level) = 22 m
Stack Diameter (ID) = 1.2 m
Flue Gas Flow Rate (Dry Standard) = 244 dscmm
Flue Gas Exit Temperature = 356 K
Flue Gas Exit Velocity (Actual) = 266 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	9.12E-03	1.33E-01	1.000	8.00E-01
Other TCDD	1.62E+00	2.37E+01	.010	1.42E+00
2378 TCDF	ND (N/A)	ND (N/A)	.100	ND (N/A)
Other TCDF	4.46E+00	6.52E+01	.001	3.91E-01
Penta-CDD	4.19E-02	6.12E-01	.500	1.84E+00
Penta-CDF	1.28E+00	1.88E+01	.100	1.13E+01
Hexa-CDD	1.24E-01	1.82E+00	.040	4.37E-01
Hexa-CDF	ND (7.30E-02)	ND (1.07E+00)	.010	ND (6.40E-02)
Hepta-CDD	3.03E-01	4.43E+00	.001	2.66E-02
Hepta-CDF	7.82E-02	1.14E+00	.001	6.86E-03
Octa-CDD	5.50E-01	8.04E+00	.000	.00E+00
Octa-CDF	3.65E-02	5.33E-01	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				1.62E+01

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
6000 operating hours per year

TABLE F-3. RISK MODELING PARAMETERS FOR RUN 11, SITE SSI-A (SCRUBBER OUTLET LOCATION)

Stack Height (From Grade Level) = 22 m
Stack Diameter (ID) = 1.2 m
Flue Gas Flow Rate (Dry Standard) = 227 dscmm
Flue Gas Exit Temperature = 353 K
Flue Gas Exit Velocity (Actual) = 262 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	4.49E-03	6.11E-02	1.000	3.67E-01
Other TCDD	1.38E+00	1.87E+01	.010	1.12E+00
2378 TCDF	ND (N/A)	ND (N/A)	.100	ND (N/A)
Other TCDF	4.99E+00	6.79E+01	.001	4.07E-01
Penta-CDD	ND (3.04E-02)	ND (4.14E-01)	.500	ND (1.24E+00)
Penta-CDF	1.51E+00	2.06E+01	.100	1.24E+01
Hexa-CDD	1.10E-01	1.49E+00	.040	3.58E-01
Hexa-CDF	7.29E-02	9.91E-01	.010	5.95E-02
Hepta-CDD	4.13E-01	5.62E+00	.001	3.37E-02
Hepta-CDF	8.19E-02	1.11E+00	.001	6.68E-03
Octa-CDD	9.78E-01	1.33E+01	.000	.00E+00
Octa-CDF	ND (4.11E-02)	ND (5.59E-01)	.000	ND (.00E+00)
Net 2378 TCDD Equivalent Atmospheric Loading				1.47E+01

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
6000 operating hours per year